



DESIGN TECHNICAL MEMORANDUM

REMEDIATION OF IMPACTED SOILS

GRANVILLE SOLVENTS SITE GRANVILLE, OHIO

Submitted to:

**The United States Environmental Protection Agency
Emergency Response Branch, Region V
Chicago, Illinois**

Developed for:

**Granville Solvents PRP Group
Columbus, Ohio**

July 6, 1995



Metcalf & Eddy

An Air & Water Technologies Company

**2800 Corporate Exchange Drive, Suite 250
Columbus, Ohio 43231
(614) 890-5501**



Metcalf & Eddy

An Air & Water Technologies Company

July 6, 1995

Mr. Edward J. Hanlon, Project Coordinator
U.S. Environmental Protection Agency, Region 5
Office of Superfund, Remedial & Enforcement Response Branch
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

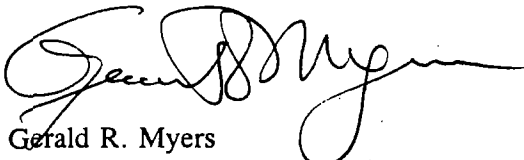
**Subject: Design Technical Memorandum
Remediation of Impacted Soils
Granville Solvents Site
Granville, Ohio**

Dear Mr. Hanlon:

Please find enclosed two copies of the above referenced report for the Granville Solvents Site Source Area Soils. We would like to have this document incorporated into the agenda for our meeting on July 10, 1995. If you have questions regarding this submittal, please contact Ben Pfefferle at (614) 469-3200 or me at (614) 890-5501.

Respectfully,

METCALF & EDDY, INC.



Gerald R. Myers
Vice President/Project Coordinator

cc: B. Pfefferle, Chairman - Steering Committee
M. Raimonde, M&E
S. Acree, U.S. EPA
F. Myers, Ohio EPA
D. Plunkett, Granville

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1.0 INTRODUCTION

The objective of this Design Technical Memorandum (DTM) is to present an overview of the current plans to address the impacted soils at the Granville Solvents Site (GSS). This DTM includes a summary of GSS background information and available soil data, presents risk-based preliminary remediation goals (PRGs) for contaminants in the site soils, provides a preliminary evaluation and screening of candidate remedial alternatives for the impacted soils, and presents a plan for the collection of additional site soil data which will assist in the evaluation, analysis, and design of a remedial alternative for the GSS soils. The information and plans presented in this DTM were prepared with the intent that they will ultimately satisfy the remediation requirements for the GSS soils as stated in the September 1994 Administrative Order by Consent for the GSS.

The development of risk-based PRGs for the GSS soil contaminants (see Section 3.0) and the preliminary evaluation of candidate GSS soil treatment alternatives (see Section 4.0) are two fundamental tasks which will support subsequent GSS source area soil project tasks. The PRGs were used to assist in the screening and evaluation of candidate treatment alternatives for the GSS soils and will ultimately be used to develop cleanup goals for contaminants in the GSS soils. Furthermore, the preliminary evaluation of candidate soil treatment alternatives serves to eliminate numerous technologies and remedial actions based on technical feasibility, site-specific conditions, and cost considerations and allows future project tasks (i.e., plans for the collection of additional site soil data) to be developed and prepared with a focus on the most promising of the treatment alternatives.

2.0 SUMMARY OF SITE BACKGROUND INFORMATION AND SOIL DATA

2.1 BACKGROUND INFORMATION

The GSS is located at 300 Palmer Lane in Granville, Licking County, Ohio. Granville Solvents, Inc. (GSI), operated as a petroleum bulk storage, distribution, and recycling facility in Granville, Ohio, at this location from 1958 until approximately 1980. The facility handled petroleum-related products such as aviation fuels and antifreeze. In 1980 or earlier, operations changed to recycling and reclaiming solvents under a RCRA Part A Permit. GSI ceased operations after failure to obtain a RCRA Part B Permit. In 1990 and 1991, the Ohio EPA removed storage tanks and drums from the Site and installed and sampled groundwater monitoring wells. Analytical results indicated that groundwater was impacted with chlorinated hydrocarbons in the vicinity and west of the GSI property.

The GSS is situated on alluvial terrace deposits at the northern edge of the Raccoon Creek Valley. The valley is underlain in places by up to 200 feet of unconsolidated sediment consisting of predominantly sand and gravel outwash with varying amounts of silt and clay. The GSS is directly underlain by unconsolidated sediments consisting of clay, silt, and sand deposited on the Raccoon Creek Floodplain. These soils are characterized by a very low permeability. Bedrock in the valley and surrounding uplands consist of sandstone, siltstone, and shale. The water table is at an average depth of 20 to 22 feet below the ground surface at the GSS.

Located approximately 650 feet west of the property is one of three Village of Granville water production wells. In the last quarter of 1993, chemical analysis of groundwater collected from a monitoring well located approximately 450 feet east of the Village production well indicated that dissolved chlorinated hydrocarbons were present. In early January 1994, the Ohio EPA recommended that the Village of Granville remove this well from service to potentially reduce capture of the impacted groundwater. The Village of Granville complied with this request.

2.2 ADMINISTRATIVE ORDER BY CONSENT INFORMATION

Based on the preliminary findings of the Ohio EPA, the U.S. EPA identified the Potentially Responsible Parties (PRPs) who allegedly shipped solvent-type material to the GSI facility for recycling, consistent with GSI's Ohio EPA RCRA Part A Permit. In January 1994, the U.S. EPA proposed that the PRPs execute an Administrative Order by Consent (AOC) with the U.S. EPA. A group of the PRPs voluntarily formed a group called the Granville Solvents Site PRP Group (PRP Group) in February 1994, and employed Metcalf & Eddy, Inc., in March 1994 to begin site work to collect data necessary to design and implement Removal Actions. Certain members of the PRP Group and the U.S. EPA voluntarily signed the AOC in September 1994. The AOC includes requirements for the project site:

- 1) By December 20, 1994, a groundwater extraction treatment system shall be installed and operational. The treatment system shall halt the migration of groundwater contamination (originating from the site) toward the Village of Granville municipal wellfield.
- 2) Implement the appropriate actions necessary to ensure that any contaminated water (originating from the site) that enters the Village of Granville municipal wellfield drinking water supply meets all risk-based and applicable federal and state drinking water standards.
- 3) The groundwater treatment system shall treat all groundwater within the contamination plume originating from the site to no further action levels which assure protection of human health and the environment and attain all risk-based standards and federal and state applicable or relevant and appropriate requirements (ARARs). The groundwater treatment system shall continue to operate (and the treatment system performance monitored) until the AOC is terminated.
- 4) Site soils shall be treated to levels which will assure protection of human health and the environment, to levels which will attain all risk-based standards and federal and state ARARs, and to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels.

2.3 GROUNDWATER TREATMENT SYSTEM INFORMATION

In December 1994, a groundwater pump and treat system was installed at the GSS to collect and treat impacted groundwater beneath the site. The groundwater treatment system consists of two extraction wells (GSS-EW1 and GSS-EW2) equipped with submersible pumps, a low profile air stripper, transfer pumps, and transfer piping. Figure 2-1 (attached) provides an illustration of the extraction well locations and representative groundwater potentiometric surface conditions during operation of the treatment system. The groundwater potentiometric surface conditions illustrated in Figure 2-1 provide evidence of the control and capture of groundwater beneath the GSS and the resulting control of contaminants present in the site groundwater. Pumping rates for extraction wells GSS-EW1 and GSS-EW2 averaged 200 gpm and 90 gpm respectively from the commencement of system operations in December 1994 through mid-February 1995. Pumping rates for each extraction well averaged 90 gpm from mid-February through mid-April. Based on influent and effluent analysis results from the groundwater pump and treat system, an estimated 60 pounds of organic compounds were removed from the site groundwater between mid-December 1994 and mid-April 1995.

2.4 SAMPLING INVESTIGATIONS AND SOIL DATA

To date, some limited soil sampling activities have been conducted at the GSS to assist in identifying the nature and extent of site soil contamination. The soil data resulting from these sampling investigations indicates the presence of volatile organic compounds (VOCs) in the site soils, particularly chlorinated hydrocarbons including tetrachloroethene (PCE), trichloroethene (TCE), trichloroethane (TCA), dichloroethene (DCE), and dichloroethane (DCA). The highest concentrations of these contaminants have been observed in the immediate vicinity of the warehouse building. Based on available site data, the soil contaminant concentrations appear to decrease with distance from the site buildings and are limited to the GSI property. Contaminants were detected in the soils at depths ranging from just below the ground surface (2 to 4 feet) to immediately above the water table (generally 20 to 22 feet below the ground surface). The following paragraphs provide a summary of the soil sampling investigations performed at the site.

In June 1991, Compliance Solutions, Inc. was retained by the Ohio EPA to install several groundwater monitoring wells and collect and analyze soil samples from the GSS. A total of 14 monitoring wells were installed between June 1991 and May 1992. Soil cuttings from the boreholes used to install the

monitoring wells were monitored using a photoionization detector (PID) during this investigation. Soil samples were also collected from some of the boreholes using a split spoon sampler. These samples were submitted to an EPA contract laboratory for volatile organic compound (VOC) analysis. Figure 2-2 provides the monitoring well locations for this investigation. Table 2-1 provides the soil analytical results for the samples that were submitted for VOC analysis. Attachment A of this DTM provides the available boring logs (including PID readings) for this investigation.

In addition to the soil sampling and analysis activities associated with the installation of site monitoring wells, the contractor retained by the Ohio EPA collected a soil sample from a sump located in the northeast corner of the warehouse building (18-inch depth) and three soil samples near the northwest corner of the warehouse building (3-, 20- and 26-foot depths). The soil sample from the sump was analyzed for VOCs, semi-volatile organics, pesticides, herbicides, metals, and cyanide. The soil samples from the northwest corner of the warehouse building (location MW-P1 on Figure 2-2) were analyzed for VOCs. Tables 2-2 and 2-3 provide the analytical results for the constituents detected in these soil samples.

Additional soil sampling at the GSS was performed by M&E under the direction of the PRP Group in April and May of 1994. During this investigation, a total of 48 soil samples were collected and analyzed by M&E's Close Support Laboratory which employed a heated headspace analysis to determine the presence of PCE, TCE, TCA, and DCE. In addition, 8 of these samples were duplicated and submitted to an off-site laboratory and analyzed for VOCs (U.S. EPA Method 8020). Figures 2-3 and 2-4 provide an illustrative summary of the analytical data resulting from this sampling investigation.

In addition to the sampling and analysis of the site soils, M&E also conducted three soil vapor removal (SVR) pilot tests at the GSS to evaluate the soil permeability and the potential for removing VOCs from the site soils by simply applying a vacuum. The SVR test results indicated that the site soils have a very low air permeability in the locations that were evaluated.

3.0 RISK-BASED PRELIMINARY REMEDIATION GOALS

This section of the DTM presents health-based preliminary remediation goals (PRGs) derived for chemicals in soil and groundwater for the GSS. PRGs are concentrations or levels for chemicals of concern which serve as action levels for evaluating site conditions or as the long-term targets for selection of remedial alternatives in environmental investigations. The PRGs are also determined on a chemical- and media-specific basis. It is important to note that this memorandum is limited to the development of health-based or risk-based PRGs. The ultimate cleanup level or objectives for a chemical may not be based strictly on risk considerations. There may be cases where the risk-based PRG is below: 1) the level to which currently available remedial technologies can decrease chemical concentrations, 2) the level which can be detected with any confidence by analytical laboratories, and/or 3) the level which could be achieved within a reasonable time frame or cost.

Development of the PRGs entails the identification of chemicals of concern, development of a site conceptual model, identification of Applicable or Relevant and Appropriate Requirements (ARARs), and ultimately, calculation of risk-based chemical concentrations. The PRGs will provide a basis for identifying the target chemical concentrations in soil and groundwater which would be the goal of the remedial technologies applied at the site.

3.1 CHEMICALS OF CONCERN

The chemicals of concern were identified based on the general types of chemicals described in the Administrative Order of Consent (AOC) for the site, the analytical results of historical sampling of groundwater and soil, and sampling and analyses of soil and groundwater performed by Metcalf & Eddy, Inc., in 1994. As indicated in Table 3-1, the chemicals of concern are limited to 22 volatile organic compounds (VOCs) which have been detected in soil and/or groundwater.

3.2 CONCEPTUAL SITE MODEL

The conceptual site model (CSM), shown in Figure 3-1, was developed to present an understanding of the site dynamics for use in the preparation of health-based PRGs. The CSM also delineates important fate and transport processes. In general, the CSM provides a presentation of the matrix of potential chemical sources and migration pathways, routes of exposure, and receptors potentially subject to exposure to chemicals in the environmental media at the GSS. The CSM focuses on complete exposure pathways. For an exposure pathway to be complete the following components must all be present: a source, a release mechanism, a transport medium, an exposure point, and a receptor.

Exposure pathways describe the movement of chemicals from sources to media where exposed populations (receptors) could potentially come in contact with the chemicals. Exposure routes describe the modes of contact and intake of chemicals in environmental media at exposure points. For example, trichloroethene in the soil (the source) at the Granville site could be encountered or uncovered during drilling or excavation activities and released as a vapor (through a volatilization release mechanism) into the air (the transport medium). The air containing the trichloroethene could then be breathed by the driller or excavator (through inhalation at the exposure point). This is a hypothetical scenario and such exposure pathways would be prevented through Health and Safety Practices enforced at the site. However, the example is illustrative of how the CSM is developed to characterize how exposures or contact with site-related chemicals might occur.

The development of a CSM is an iterative process which can result in changes in the model as site-specific information is obtained. It should be noted that development of the conceptual site models has been based only on information available to date from the site. These data indicate that the two primary sources of chemicals at the Granville site are chemicals in soil and chemicals in groundwater.

The human populations, individuals, or receptors who could feasibly be exposed to chemicals from the site are key to the process of developing risk-based PRGs. Risk-based PRGs ultimately should reflect the chemical concentration which will be protective of the receptor populations. The potential receptors of concern for the Granville site include:

On-Site Environmental Investigation Workers

Individuals who participate in sampling activities (such as drillers or environmental workers) could feasibly come into contact with chemicals in soil or groundwater. However, these workers are trained to avoid such contact and must take protective measures and wear protective equipment and clothing to prevent chemical exposures. It would be expected that such sampling would not require more than one week per quarter over an indeterminate number of years.

On-Site Excavation Workers

Individuals may come onto the site to perform excavation activities and could feasibly come into contact with chemicals in soil. However, these workers are trained to avoid such contact and must take protective measures and wear protective equipment and clothing to prevent chemical exposures. Further, the workers could perform digging activities in machinery with enclosed operator cabs and purified/filtered ventilation systems which would be further protective against exposure. It would be expected that such work would occur on an intermittent basis.

Off-Site Bikeway User

Individuals utilize the bikeway adjacent to the Granville site for walking, jogging, biking, etc. Because the site premises are enclosed by a fence, the bikeway users cannot enter onto the property. Therefore, the only feasible means for potential exposure would be through contact with chemicals emitted as vapors from site soils. Such exposure would be expected to be very short in duration because the bikeway segment at the site is limited to the length of the southern boundary of the site.

Off-Site Resident

Individuals live in homes located to the north, northeast, and northwest of the Granville site. Because the site premises are enclosed by a fence, the residents cannot enter onto the property. Therefore, the only feasible means for potential exposure would be through contact with chemicals which have been emitted as vapors from site soils or which have migrated off-site in groundwater.

3.3 ARARS REVIEW

ARARs for chemical release sites include cleanup standards, standards of control, and other enforceable federal, state and local environmental regulations and requirements for environmental protection. These

standards and requirements may specifically address a hazardous constituent, remedial action, location, or other circumstances at a site. As such, ARARs are categorized as follows:

- Chemical-specific requirements
- Action-specific requirements
- Location-specific requirements

Drinking Water ARARs and Action Levels

Chemical-specific ARARs for the site are primarily limited to U.S. EPA Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for drinking water and Ohio EPA MCL standards for public water supplies. A summary of the MCLs for the chemicals of concern which have been developed by U.S. EPA and Ohio is provided in Table 3-2.

U.S. EPA Regions III and IX have developed generic risk-based action levels or PRGs for chemicals in drinking water. A summary of these action levels is provided in Table 3-3. The U.S. EPA Region III and IX PRGs are derived based on a generic residential use scenario.**

Soil Action Levels

For direct contact with chemicals found in soils, U.S. EPA has developed draft Soil Screening Levels (SSLs) for some of the chemicals of concern. These SSLs are generic for residential exposure to soils. In addition, risk-based soil action levels have also been developed by U.S. EPA Regions III and IX for residential and occupational exposure to soils. A summary of the various U.S. EPA soil PRGs for the chemicals of concern is provided in Table 3-4.

Finally, U.S. EPA and U.S. EPA Region III have also derived SSLs or action levels for soil which are targeted to be protective of groundwater. These action levels were developed with the goal that release of chemicals from soil to groundwater would not result in chemical concentrations which would be higher than risk-based drinking water concentrations. A summary of the SSLs and action levels is provided in Table 3-5.

*Sub surface soils
- variability in sampling methods
and what USGS data
for 10-15' for risk*

3.4 SITE-SPECIFIC RISK-BASED PRELIMINARY REMEDIATION GOALS

Site-specific PRGs for soil and groundwater can be calculated. The derivation of such PRGs is based on achievement of a specific criterion for noncancer hazard and carcinogenic risk endpoints. The potential for noncarcinogenic effects is evaluated by comparing exposure level estimates to toxicity levels developed by U.S. EPA (below which noncancer effects would not be expected/predicted to occur). The criterion for noncancer effects should be such that the ratio between estimated exposure (relative to site-related chemical concentrations) and the associated U.S. EPA-developed toxicity value does not exceed unity. For carcinogenic effects, the criterion is based on the estimated probability for cancer development. For exposure to chemical carcinogens at sites where hazardous substances have been released, U.S. EPA's NCP requires that estimated lifetime cancer risk at a particular site should fall within the range of 1 in 10,000 ($1E-04$) and 1 in 1,000,000 ($1E-06$). Similarly, the Ohio EPA's "How Clean is Clean Policy" adopts similar guidelines, stating that acceptable exposure levels are generally concentrations that represent a cumulative excess upper bound lifetime cancer risk to an individual between $1E-04$ and $1.0E-06$.

Chemical concentrations in environmental media which are associated with noncancer hazard levels of unity and carcinogenic risk levels of $1E-06$ can be computed in much the same manner as the generic U.S. EPA residential and occupational action levels described in the ARARs Review, the U.S. EPA has published guidelines for the development of such PRG concentrations; these guidelines serve as the primary basis for calculating the soil concentrations associated with specific health-related criteria (Human Health Evaluation Manual, Part B: "Development of Risk-Based Preliminary Remediation Goals", OSWER Directive 9285.7-01B, December 13, 1991).

Development of the PRGs requires the selection of the maximally exposed receptors identified in the CSM. A description of the equations and the assumptions utilized for the parameter values in the calculation of the human health PRGs is provided in Appendix A. Soil and groundwater PRGs were based primarily on oral and/or inhalation exposures. Current guidelines do not provide for the development of PRGs for dermal exposure to soil or groundwater. The PRGs were calculated on an exposure-specific and a chemical-specific basis. A target risk level of $1.0E-06$ risk was used for each carcinogenic endpoint. Similarly, a target hazard quotient of 1.0 was employed for each chemical in the calculation of PRGs for non-cancer endpoints. The chemical-specific toxicity factors utilized in the

derivation of the soil PRGs and the resulting PRGs for the oral, inhalation, and combined oral and inhalation exposure routes are also provided in Appendix A.

Table 3-5 provides a summary of the site-specific PRGs calculated for the chemicals of concern at the Granville site. The PRGs were calculated for direct contact exposures for the two primary on-site human receptor populations, namely potential excavators of site soils and environmental samplers. The two primary off-site receptors examined were residents of the homes in the vicinity of the site and pedestrians/bike riders who may traverse the portion of the bikeway which is located adjacent to and along the length of the site.

Additionally, PRGs were developed to provide protection from groundwater assuming that soil concentrations have the potential to migrate to groundwater. The PRGs calculated for groundwater protection are also provided in Table 3-5. These PRGs were developed with the goal that release of chemicals from soil to groundwater would not result in chemical concentrations which would be higher than U.S. EPA or Ohio EPA MCLs or U.S. EPA Regions III or IX health-based groundwater concentrations. In addition to the site-specific PRGs, the U.S. EPA and U.S. EPA Region III soil action levels for the protection of groundwater are presented for comparison purposes. It should be noted that these action levels are derived to prevent chemical migration which would exceed risk-based rather than MCL-based groundwater concentrations. In all cases, the soil action levels have been derived assuming conservative leach-based fate and transport processes.

The primary uncertainties associated with the development of the PRGs lie in the populations which may be exposed and the fate and transport processes for chemicals in soil and groundwater. With respect to the potentially exposed populations, the environmental workers represent a population whose exposure would be expected to be limited. At present, minimal off-site migration of chemicals is expected through air emissions pathways. Therefore, it is not anticipated that more restrictive soil levels would be required. The site-specific information such as air monitoring information or dispersion modeling would be helpful in further substantiating the assumption of minimal off-site chemical emissions.

3.5 SUMMARY OF PRG DEVELOPMENT

Risk-based PRGs were developed in this section. The PRGs will be used in the evaluation and selection of remedial technologies for soil and groundwater at the GSS. Risk-based PRGs are levels in soil and groundwater which would protect any individuals who could come in contact with site soils and groundwater from adverse health effects. The goal of this evaluation was to identify the population group that could have the most contact with site soils and groundwater and the PRGs which would protect these individuals from adverse health effects. Environmental workers (involved in sampling or excavation activities) will likely be the only population group who will have access to the site in the future and come into contact with site soil. People who would use groundwater for drinking water are likely to have the most contact with chemicals in groundwater. Finally, chemicals in soil could be transferred into groundwater which ultimately is used for potable purposes (such as for drinking water, bathing/showering, cooking, etc.).

Soil and groundwater levels which will be health protective for people who might use untreated groundwater for drinking water are summarized in Table 3-6. The PRG evaluation showed that a potential movement of chemicals from soil to groundwater results in the lowest PRGs for soil. PRGs to protect workers from direct contact with chemicals in soil would be higher than the PRGs for chemical transfer from soil to groundwater. The soil PRGs which are protective of groundwater are the lowest values derived by the U.S. EPA as soil screening levels. The groundwater PRGs are maximum contaminant levels (MCLs) or, for chemicals for which MCLs are unavailable, the lowest risk-based PRG for drinking water.

This discussion identifies ranges of potential receptor populations, exposure assumptions, and fate and transport factors which must be considered in selecting the appropriate remediation strategy for the site. A primary concern is how the site will be controlled and used in the future. The PRGs represent the highest levels which could be considered for the site. If more extreme assumptions about exposed populations or chemical fate and transport are of issue, the PRGs would likely be lower for some or all of the chemicals.

3.6 REFERENCES

- U.S. EPA. 1995. U.S. Environmental Protection Agency. Drinking Water Regulations and Health Advisories. Office of Water. April 1995.
- U.S. EPA. 1991. U.S. Environmental Protection Agency. Human Health Evaluation Manual Part B: "Development of Risk-Based Preliminary Remediation Goals." OSWER Directive 9285.7-01B. December 13, 1991.
- U.S. EPA. 1993. U.S. Environmental Protection Agency. Drinking Water Regulations and Health Advisories. Office of Water. May 1993.
- U.S. EPA. 1989. Risk Assessment Guidance for Superfund. Human Health Evaluation Manual. Part A. OSWER Directive 9285.7-01a. September, 1989

4.0 EVALUATION OF CANDIDATE SOIL TREATMENT ALTERNATIVES

This section of the DTM has been prepared to provide an evaluation of treatment alternatives for the impacted soils at the GSS. This evaluation is considered preliminary at this time, and will be revised as appropriate based upon the collection of additional data at the GSS. The evaluation presented below is based on available site data (see Section 2.0 of this DTM) and the preliminary remediation goals (PRGs) which have been developed for the site soils (see Section 3.0 of this DTM).

4.1 TREATMENT ALTERNATIVE EVALUATION

Lists of both established and innovative treatment technologies have been developed for the impacted soils at the Granville Solvents site. Tables 4-1 and 4-2 provide a preliminary screening of these technologies based on anticipated effectiveness (i.e., will the technology achieve the PRGs for the site soil contaminants), technical feasibility, and site-specific conditions. The screening comments in Tables 4-1 and 4-2 provide the specific rationale used to retain or eliminate a given technology or remedial action. The noteworthy advantages and disadvantages associated with each technology or action are also noted in Tables 4-1 and 4-2. As noted in Tables 4-1 and 4-2, a wide range of site remedies, including capping without treatment, in-situ treatment, ex-situ treatment, and off-site disposal with or without treatment were considered as a part of the remedial alternative evaluation process. When the cost of remediation is considered, in-situ treatment technologies would be preferred over ex-situ technologies based on the costs associated with excavation, materials handling, and disposal or replacement of the excavated soils. Furthermore, the higher cost of ex-situ treatment and off-site disposal alternatives provides justification for the expenditure of additional capital to collect additional site data and perform treatability studies to evaluate in-situ treatment technologies (including innovative technologies) which, if deemed technically feasible, may result in effective cleanup at a substantial cost savings. Based on the results of the preliminary screening of candidate treatment technologies presented in Tables 4-1 and 4-2, the following established remedies and innovative remedies have been retained for further consideration for the impacted soils at the Granville Solvents Site:

ESTABLISHED REMEDIES

Capping
Off-Site Disposal
Bioremediation
Soil Vapor Extraction

INNOVATIVE REMEDIES

Enhanced Volatilization
Low Temperature Thermal Desorption
In-Situ Mixing/Steam Stripping
Soil Flushing

The following sections provide a description of the established and innovative remedial alternatives which have been retained for possible application to the site soils. It should be noted that all innovative technologies and bioremediation and soil vapor extraction would require the performance of site-specific treatability study tests to provide the data necessary to evaluate thoroughly the potential effectiveness of these technologies.

4.1.1 Established Remedies

Capping

Capping is a remedial action which serves to prevent surface water from collecting and transporting contaminants through soil and into the underlying groundwater. Capping also reduces the potential for direct physical contact with contaminated soils. Capping is most appropriate for sites where contamination is extensive and excavation or treatment is unrealistic due to technical infeasibility, potential hazards to humans, or prohibitively high costs.

Various designs can be used to construct a cap and cover system over areas which contain contaminated soil. Common cap designs include those which comply with RCRA requirements for hazardous waste landfill covers (RCRA Subtitle C) and those which comply with state requirements for non-hazardous solid waste landfill covers. Other more simple designs may include a layer of low-permeability clay with a vegetative cover, concrete, or asphalt. All cap and cover systems will require long-term maintenance to ensure the continued effectiveness of the cap and cover system in reducing surface water infiltration and reducing the potential for direct physical contact with contaminated soils.

Off-Site Disposal

Hazardous Waste Landfill

This remedial action would entail excavating the impacted site soils with heavy construction equipment and disposing of the untreated soils at a hazardous waste landfill. Hazardous waste landfills are designed and operated in accordance with the standards established by the Resource Conservation and Recovery Act (RCRA). Implementation of this technology is restricted by increasingly stringent regulatory controls. Based on available analytical results for the site soils, RCRA land disposal restrictions may apply to some of the site soils. Land disposal restriction would require that the soils be treated prior to off-site disposal at a hazardous waste landfill.

Solid Waste Landfill

This remedial action has been retained for consideration as a possible follow-on component for soils that may be excavated and treated on-site. Disposal of treated soils at a solid waste landfill is a widely practiced remedial action component. However, the potential presence of residual contamination in the site soils, the increasing demand for solid waste landfill space, and the fact that the soils to be disposed will have originated from a CERCLA site are issues which will make solid waste landfill disposal of the site soils very difficult from an administrative standpoint.

Bioremediation

Bioremediation is a treatment technology that may be used to treat organic contaminants in soil. Bioremediation technologies involve enhancing the biological degradation of organic contaminants through

the stimulation of indigenous microbial populations or through the addition of natural microbial species. Typical ex-situ bioremediation technologies include:

- Slurry-Phase Treatment
- Land Treatment
- Contained Solid-Phase Treatment

Slurry-phase bioremediation involves mixing excavated soil with water to create a slurry that is mechanically agitated in a treatment vessel (e.g., a tank) and mixed with the appropriate combination of nutrients and oxygen at the proper pH, (acidity) and temperature. Upon completion of the treatment process, the slurry would be dewatered and the treated soil would be placed on site or disposed of off-site. Dependent upon the residence time required for the degradation process, the slurry-phase treatment system may be operated in batch or semi-continuous mode.

Bioremediation via land treatment involves placing contaminated soils in a lined treatment bed in a series of lifts (several inches thick). Between each lift, supplements such as manure and other nutrients would be mixed with the soils to enhance the biological degradation of the soil contaminants. The land treatment process would also include periodic cultivation of the soils to stimulate the biological degradation process.

Contained solid-phase biological treatment refers to a variety of treatment processes whereby excavated soils are mixed with nutrients and arranged in piles or placed in a treatment tank. The temperature and pH of the soils can be controlled throughout the treatment process. In addition, organic emissions from the piles or treatment tank may also be captured and treated.

Soil Vapor Extraction

Soil Vapor Extraction (SVE) is a treatment technology whereby air is withdrawn from impacted soils through a series of vapor extraction wells which have been installed and screened in contaminated soils. The air that is withdrawn through the extraction wells via vacuum pumps or blowers is replaced by ambient air. The resulting movement of air through the soil column serves to volatilize the volatile organic contaminants in the soils and facilitate removal of the contaminants. The contaminants that are removed via the extraction well air stream may require collection/treatment prior to discharge to the

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- . Slurry-Phase Treatment
- . Land Treatment
- . Contained Solid-Phase Treatment

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atmosphere. Carbon adsorption, thermal destruction, and condensation are some of the more common treatment technologies which may be employed to remove the organic contaminants from the air stream prior to discharge to the atmosphere. In many cases, the SVE treatment system may include a vapor-liquid separator to remove the moisture from the exit gas, thereby protecting the system blowers and increasing the efficiency of the vapor treatment process.

Pilot testing of this treatment technology at the Granville Solvents site indicated that the low-permeability of the clay-rich site soils prevented effective SVE treatment. Therefore, alteration of the site conditions would be necessary to facilitate effective treatment via SVE. Horizontal drilling and pneumatic fracturing are among the technologies currently available which may increase the permeability of the site soils and facilitate effective treatment of the site soils via SVE. Additional study and evaluation of these technologies is necessary to determine which technology would be most effective and appropriate for this application.

4.1.2 Innovative Remedies

Enhanced Volatilization

Enhanced volatilization is a treatment process whereby excavated soils are processed using mechanical equipment (shredders, a hammermill, and pugmill) to facilitate the release of volatile organic contaminants from the soil. Dependent upon the concentration of contaminants in the treatment system air stream and the applicable regulatory requirements, the air stream may require additional treatment via carbon adsorption, thermal destruction, or condensation to reduce the concentration of organic constituents prior to discharge.

Low-Temperature Thermal Desorption

Low-Temperature Thermal Desorption (LTTD) is a technology which may be used to remove volatile organic contaminants from soil. The LTTD process employs aeration and heat to volatilize and drive off organic compounds from contaminated soil. LTTD systems heat contaminated soils to temperatures between 200 F and 1,000 F, driving off water and volatile contaminants in the soil matrix. As with the enhanced volatilization treatment process, the concentration of organic contaminants in the off-gas and

regulatory requirements may dictate a need for off-gas treatment via carbon adsorption, thermal destruction, or condensation.

In-Situ Mixing/Steam Stripping

In-situ mixing/steam stripping is a treatment technology designed to volatilize and subsequently capture and treat volatile organic contaminants in soil. The treatment unit consists of two major elements, a process tower and an off-gas treatment system. The process tower's major components include two hollow augers to drill into and mix the soil, cutter bits to inject steam and hot air into the soil, and a treatment shroud which covers the ground surface above the augers to collect the volatilized soil vapors and direct the vapors into the off-gas treatment system. The gas treatment system's major components include a scrubber to remove entrained particulates, a cyclone separator to remove entrained water droplets, a cooling system which condenses water vapor and volatile organic compounds in the gas stream, a distillation unit which serves to separate water and organic compounds in the condensed liquid stream, a carbon adsorption system that removes residual organic contaminants in the gas stream, and a compressor that serves to increase the temperature and the pressure of the treated gas stream prior to reinjection into the soil. The in-situ mixing/steam stripping process has been successfully demonstrated to remove volatile organic compounds from low-permeability (clay rich) soils at several contaminated sites throughout the U.S.

Soil Flushing

Soil flushing is an in-situ treatment process designed to mobilize soil contaminants for the purpose of recovery and treatment. Soil flushing uses water, enhanced water, or gaseous mixtures to accelerate subsurface contaminant transport mechanisms. Soil flushing is generally most effective in homogeneous, permeable soils (e.g., sands or silty sands with greater than 10^{-4} cm/sec permeability). This technology has several associated limitations including: the generation of large quantities of elutriate which will require treatment; general ineffectiveness at sites where the soil contaminants are tightly bound to the soil (as is the case at the Granville Solvents Site); the potential for problematic interactions of surfactants in the flushing solution with the biological, physical, and chemical properties of the unsaturated zone; and uncertainties in the overall reliability of the soil flushing technology due to limited experience in the technology's at contaminated sites to date.

5.0 SOIL DATA COLLECTION PLAN TO SUPPORT ENGINEERING DESIGN ACTIVITIES

This section of the DTM provides a summary of the plans to collect and analyze soil samples from the GSS. The data resulting from the sample collection and analysis activities will be used to perform a further engineering evaluation and cost analysis of candidate treatment technologies for the impacted GSS soils. Both physical and chemical soil data will be obtained during the sampling investigation. The plan to obtain the physical and chemical soil data from the GSS is presented below.

5.1 BASIS FOR SAMPLING PLAN DEVELOPMENT

This DTM sampling plan presents the proposed approach to collect additional GSS soil data which will support the evaluation of several candidate treatment technologies and ultimately assist in the preliminary design and implementation of a soil treatment remedy. As presented in Section 3.0 of this DTM, the candidate treatment technologies currently under consideration for the GSS soil are limited to the following:

- Excavation and Bioremediation
- In-Situ Soil Vapor Extraction¹
- Excavation and Low Temperature Thermal Desorption
- Excavation and Enhanced Volatilization
- In-Situ Mixing/Steam Stripping
- In-Situ Soil Flushing

The following is a summary of the process used to develop the sampling plan for the GSS soils:

1. The physical and chemical data requirements for the evaluation of candidate treatment technologies were identified.
2. Chemical data requirements for the estimation of the vertical and horizontal extent of site soil contamination were identified.

¹ Based on the results of pilot SVE tests previously performed at the GSS, increasing the air permeability of the site soils via pneumatic fracturing or a similar technology will be necessary in some areas of the site to facilitate effective soil treatment via SVE.

3. A cost/benefit analysis for the collection of additional site data was performed.

The following DTM subsections provide a description of the proposed GSS soil sampling plan and supporting information used to develop the plan.

5.2 PHYSICAL SOIL DATA COLLECTION PLAN

With respect to the physical soil data needs for these treatment technologies, treatment vendors specializing in these technologies have been contacted to develop a list of data needs for each technology. Table 5-1 provides a summary of these data needs. Based on these data needs, the following tests will be performed on the soil samples which are collected for physical analyses:

- Moisture Content
- Grain Size Sieve Analysis
- Bulk Density
- Atterberg Limits
- Soil pH
- Bacterial Enumeration
- Biodegradation Confirmation***
- Total Organic Carbon ✓

The soil samples for physical analyses will be collected from ~~six~~ different site locations. Based on M&E's current understanding of the site characteristics and stratigraphy, the GSS was broken into three separate areas to select the locations for the collection of physical soil samples. These areas include the Flood Plain Area, the Glacial Terrace, and the Fill Area. Soil samples from two different locations within each of these areas will be collected and analyzed for the physical parameters noted above. This sampling plan is expected to provide physical soil data which is representative of the soils in the three different site areas.

5.3 CHEMICAL SOIL DATA COLLECTION PLAN

Chemical soil data will be used to estimate the horizontal and vertical extent of soil contamination at the GSS. A plan for the collection of chemical soil data from the GSS has been developed to support a fairly concise delineation of soil contaminant boundaries at the site. An accurate delineation of soil contaminant boundaries is necessary to provide the information required to assist in the evaluation, selection, development, and design of a treatment remedy for the impacted site soils.

A common set of conditions and rationale was used in developing the chemical sampling and analysis plan for the Granville Solvents Site. These conditions and rationale are summarized below:

- The sampling plan was developed with the understanding that the contaminants in the site soils are the result of leaks from underground storage tanks and surface spills in the warehouse area. Based upon this understanding, the contaminant concentrations in the site soils are expected to be highest near these source areas and become progressively lower as the distance from these source areas increases. The sampling plan has not been designed to identify isolated areas of contamination or contaminant "hot spots".
- Based on the available site data, the soils by the warehouse and former tank farm will be considered to be impacted. Consequently, only limited sampling is proposed in this area. Figure 5-1 provides an illustration of this area. The impacted soil area, designated as Area A for the purposes of this discussion, covers approximately 7,200 square feet. Available site data indicate that the Area A soils are generally impacted down to the water table (approximately 20 feet deep). Based on an impacted soil depth of 20 feet, the total volume of impacted soils within Area A is approximately 5,300 cubic yards. The sampling investigation will include the collection and analysis of 12 samples from three boring locations (4 samples per boring collected at the 2- to 4-, 6- to 8-, 12- to 14-, and 18- to 20-foot intervals) in this area. Two of these boring locations are located outside the warehouse and one boring is located inside the warehouse. The analyses proposed for all soil samples are described below. The resulting data from these borings will assist in establishing "worst case" contaminant concentration conditions for the site soils and assist in the evaluation of soil treatment technologies.

- The sampling investigation will be performed in two phases. The first phase of the investigation will entail the collection and analysis of soil samples from 24 boring locations (excluding the 3 boring locations within Area A) from a 50 x 50 foot sampling grid (see Figure 5-1 for sampling locations). Upon receipt of the analysis results from the first phase of the investigation, a sampling plan for the second phase will be developed to assist in the refinement of the estimated vertical and horizontal extent of site soil contamination.

- * One soil boring will be completed within each grid block at the boring locations noted in Figure 5-1. Four samples will be collected from each boring at the ⁰² 2- to 4-, 6- to 8-, 10-12 12- to 14-, and 18- to 20-foot intervals. All samples will be analyzed for TCL VOCs (SW-8260). In addition, samples collected from the three boring locations within Area A and five of the eleven grid block boring locations immediately adjacent to Area A (see Figure 5-1) will be analyzed for TCL semi-volatile organic compounds (SW-8270) and the eight RCRA metals (SW-6010/7000s). Cost estimates for analytical costs presented in this DTM were developed with the understanding that all soil samples will be analyzed on a 14-day-turnaround time schedule.

- All soil samples will be visually screened in the field for the presence of non-aqueous phase liquids (NAPLs). A description of the procedures to be used to visually screen all soil samples for NAPL will be made available prior to the implementation of field activities.

- In estimating the amount of time required to complete the first phase of the sampling investigation, it has been planned that a total of four borings would be completed in one day (16 VOC samples/day plus 3 additional samples for QA/QC purposes, i.e., field duplicates, field blanks, and trip blanks).

5.4 COST/BENEFIT ANALYSIS AND RELATED ISSUES

To assist in the evaluation of the chemical soil data collection plan for the Granville Solvents Site, a cost/benefit analysis was performed to evaluate the cost and benefits associated with the plan's implementation. The cost to implement any sampling plan will vary in direct proportion with the number of samples collected and analyzed. The challenge in developing a sampling plan is to provide the data necessary to satisfy the project's data needs at the lowest cost. As described above, the chemical data resulting from the Granville Solvents Site sampling investigation will be used to assist in the evaluation of candidate soil treatment technologies and estimate the vertical and horizontal extent of site soil contamination which will support the design and implementation of the chosen treatment remedy. Accurate delineation of the vertical and horizontal extent of soil contamination at the site is critical because this information will serve as the basis for the sizing and design of the chosen treatment remedy for the impacted soils. Data which supports a concise determination of soil contaminant boundaries will correspondingly support the implementation of a remedial alternative which is both cost-effective and optimally designed for the soil contaminants.

For the purpose of cost/benefit analysis illustration, consider a soil sampling investigation which employs a 40-foot grid spacing for sample collection. For a given 40-foot grid block, it may be determined that samples collected from one boring within the block are impacted to a depth of 14 feet (a total impacted soil volume of approximately 830 cubic yards). Alternatively, a sampling plan which utilized a grid spacing of 20 feet over the same area (which breaks the 40 x 40 foot block into four 20 x 20 foot blocks) may determine that only one of the four borings was contaminated to a depth of 14 feet and the remaining three blocks were impacted to an average depth of 8 feet (a total impacted soil volume of 326 cubic yards). In this case, the cost of \$4,950 to complete the additional three borings using the 20 foot grid spacing would reduce the total volume of soil targeted for treatment by 504 cubic yards. Based on an anticipated treatment cost of \$50 to \$200 per cubic yard, the additional refinement in the volume of contaminated soils that is achieved by using a smaller sampling grid could result in a cost savings of \$20,000 to over \$95,000 for each 40 x 40 foot grid block.

In addition to the above, consider a phased sampling investigation whereby the first phase is completed with a grid spacing of 40 x 40 feet and a second phase is completed with the placement of a smaller grid (20 x 20 feet) in the areas where refinement of contaminant extent is deemed appropriate (e.g., there is a significant discrepancy in the contamination depth for two adjacent grid blocks). Under this scenario,

a case can be made for a more prudent expenditure of capital because the money spent on additional sampling would be used to obtain analytical data for the site areas where additional data is most needed.

The cost/benefit information presented above illustrates that the expenditure of additional money during the sampling investigation may be justified if the additional data serves to reduce the volume of impacted soil to be treated. It should be noted that the cost/benefit example presented above was developed with assumptions that may or may not reflect actual site conditions and that additional site data do not always result in a reduction in the estimated volume of impacted site soil.

TABLES

Table 2-1
Concentrations of Volatile Organic Compounds in the
Soil Cuttings From Wells 4D, 5, 7, and 7D
(Concentrations Reported in ug/kg)

Granville Solvents Site
Granville, Ohio

Compound	Well/Boring I.D.			
	MW-4D	MW-5	MW-7	MW-7D
1,2 - Dichloroethane	BDL	BDL	0.0076 (a)	BDL
Styrene	BDL	BDL	0.00727 (a)	BDL
Tetrachloroethene	161.59	BDL	BDL	BDL
1,1,2 - Trichloroethane	40.92	BDL	BDL	BDL
Trichloroethene	155.22	BDL	BDL	BDL
Total Xylenes	43.3	BDL	BDL	BDL

BDL = Below Detection Limit

Note: Samples were collected and analyzed in June 1991.

Source: Granville Solvents Interim Action Report Dated August 26, 1992, prepared by Compliance Solutions, Inc.

(a) These concentrations are presented here as reported in the above-referenced source document. However, these reported concentrations are considered suspect based upon achievable analytical detection limits.

Table 2-2
Metal, Cyanide, and Organic Constituents Detected in the Soil Sample
Collected From the Northeast Corner of the Warehouse Building
(Sample collected from a depth of 18 inches below ground surface)

Granville Solvents Site
Granville, Ohio

Constituent	Concentration (ug/kg)
Aluminum	100,000
Arsenic	2,325
Barium	60,000
Beryllium	500
Cadmium	400
Chromium	7,600
Cobalt	9,300
Copper	16,000
Iron	290,000
Lead	10,000
Manganese	335,000
Mercury	5,910
Nickel	26,000
Thallium	1,000
Vanadium	31,000
Zinc	34,000
Cyanide	30
Benzene	3,800
Cis - 1,2 - Dichloroethene	3,630
Ethylbenzene	87,700
Methylene chloride	10,800
Tetrachlorethene	204,000
Toluene	160,600
1,1,1 - Trichloroethane	242,900
Trichloroethene	202,300
Total Xylenes	297,300
Napthalene	6,060
Alpha - BHC	623
Beta - BHC	436,700

Note: Samples were collected and analyzed in October 1991.

Source: Granville Solvents Interim Action Report Dated August 26, 1992, prepared by Compliance Solutions, Inc.

Table 2-3
Organic Constituents Detected in the
Soil Cuttings From Well P1
(Concentrations Reported in ug/kg)

Granville Solvents Site
Granville, Ohio

Constituent	Sample Depth		
	3 feet	20 feet	26 feet
1,1 - Dichloroethane	BDL	BDL	221
Cis - 1,2 - Dichloroethene	117	406	187.6
Ethylbenzene	552	BDL	BDL
Styrene	516	BDL	BDL
Tetrachloroethene	177.3	226.9	2,254
Toluene	231	BDL	BDL
1,1,1 - Trichloroethane	393	1,963	1,368
Trichloroethene	1,840	1,132	2,742
Total Xylenes	88	BDL	BDL

BDL = Below Detection Limit

Note: Samples were collected and analyzed in October 1991.

Source: Granville Solvents Interim Action Report Dated August 26, 1992, prepared by

Table 3-1 Summary of Chemicals Detected in Environmental Media

Chemicals Stated in the Administrative Consent Order Volatile Organic Chemicals (VOCs)	
Chemicals Detected in the Ground Water at the Granville Solvents Site May 1994	
	1,1,1-trichloroethane 1,1-dichloroethane acetone bromodichloromethane bromoform chloroform cis-1,2-dichloroethene dibromochloromethane ethylbenzene m- & p-xylene o-xylene tetrachloroethene toluene trans-1,2-dichloroethene trichloroethene
Chemicals Detected in Hydropunch Samples at the Granville Solvents Site April and May 1994	
	1,1,1-trichloroethane 1,1-dichloroethene 1,1-dichloroethane 2-butanone 2-hexanone acetone benzene carbon disulfide chloromethane cis-1,2-dichloroethene tetrachloroethene toluene trans-1,2-dichloroethene trichloroethene vinyl chloride
Chemicals Detected in the Soils at the Granville Solvents Site May 1994	
	1,1,1-trichloroethane 1,1-dichloroethene 2-butanone acetone tetrachloroethene trichloroethene

Table 3-2 Summary of Ohio and U.S. EPA Maximum Contaminant Levels (MCLs) for Drinking Water for the Granville Solvents Site

ANALYTE	U.S. EPA MCL (ug/l) (a)	Ohio EPA MCL (ug/l) (b)
1,1,1-trichloroethane	200	200
1,1-dichloroethene	7	7
1,1-dichloroethane	-	-
2-butanone	-	-
2-hexanone	-	-
acetone	-	-
benzene	5	5
bromodichloromethane	100*	100*
bromoform	100*	100*
carbon disulfide	-	-
chloroform	100*	100*
chloromethane	-	-
cis-1,2-dichloroethene	70	70
dibromochloromethane	100*	100*
ethylbenzene	700	700
m- & p-xylene	10000	10000
o-xylene	10000	10000
tetrachloroethene	5	5
toluene	1000	1000
trans-1,2-dichloroethene	100	100
trichloroethene	5	5
vinyl chloride	2	2
Bis(2-ethylhexyl)phthalate	6	6

Sources:

- (a) U.S. EPA. 1994. Drinking Water Regulations and Health Advisories. Office of Water. November 1994.
- (b) Ohio EPA. 1994-2. Primary Drinking Water Regulations. Ohio Administrative Code (OAC) 3745-81-11 and OAC 3745-81-12. Effective September 13, 1993.

* The MCL for total trihalomethanes includes the four chemicals designated above.

Table 3-3 Summary of U.S. EPA Region III and Region IX Risk-Based Groundwater PRGs

	TAPWATER	
	Region III PRGs (ug/L) (a)	Region IX PRGs (ug/L) (b)
1,1,1-trichloroethane	1300	1300
1,1-dichloroethene	0.044	0.046
1,1-dichloroethane	810	810
2-butanone	1900	1900
2-hexanone	NL	NL
acetone	3700	610
benzene	0.36	0.39
bromodichloromethane	0.17	0.18
bromoform	2	9
carbon disulfide	21	21
chloroform	0.15	0.16
chloromethane	1.4	1.5
cis-1,2-dichloroethene	61	61
dibromochloromethane	0.1	1
ethylbenzene	1300	1300
m- & p-xylene	520	1400
o-xylene	1400	1400
tetrachloroethene	1.1	1.1
toluene	750	720
trans-1,2-dichloroethene	120	120
trichloroethene	1.6	1.6
vinyl chloride	0.019	0.02
Bis(2-ethylhexyl)phthalate	4.8	4.8

NL - Not Listed

PRG - Preliminary Remediation Goal

Sources:

(a) U.S. EPA, Region III. 1995. Risk-Based Concentration Table, January-June 1995.
March 7, 1995.

(b) U.S. EPA, Region IX. 1995 EPA Region IX Preliminary Remediation Goals (dated 02/01/95).

Table 3-4 Summary of U.S. EPA Region III and Region IX Risk-Based PRGs for Soil for Direct Contact

	RESIDENTIAL SOIL		OCCUPATIONAL SOIL		Residential EPA SSLs (ug/kg) (c)
	Region III PRGs (ug/kg) (a)	Region IX PRGs (ug/kg) (b)	Region III PRGs (ug/kg) (a)	Region IX PRGs (ug/kg) (b)	
1,1,1-trichloroethane	7000000	3200000	180000000	3000000	980000
1,1-dichloroethene	1100	38	9500	82	40
1,1-dichloroethane	7800000	840000	200000000	3900000	980000
2-butanone	47000000	8700000	1000000000	34000000	NL
2-hexanone	NL	NL	NL	NL	NL
acetone	7800000	2000000	200000000	8400000	7800000
benzene	22000	1400	200000	3200	500
bromodichloromethane	10000	1400	92000	3400	5000
bromoform	81000	56000	720000	240000	46000
carbon disulfide	7800000	16000	200000000	52000	11000
chloroform	100000	530	940000	1100	200
chloromethane	49000	2000	440000	4300	7000
cis-1,2-dichloroethene	780000	59000	20000000	200000	780000
dibromochloromethane	7600	5300	68000	23000	NL
ethylbenzene	7800000	2900000	200000000	3100000	260000
m- & p-xylene	160000000	980000	1000000000	980000	320000*
o-xylene	160000000	980000	1000000000	980000	320000*
tetrachloroethene	12000	7000	110000	25000	11000
toluene	16000000	1900000	410000000	2700000	520000
trans-1,2-dichloroethene	1600000	170000	41000000	600000	1600000
trichloroethene	58000	7100	520000	17000	3000
vinyl chloride	340	5	3000	11	2

ND - Not Determined

NL - Not Listed

SSL - Soil Screening Levels

* Indicates that this value is for mixed xylenes

Sources:

(a) U.S. EPA, Region III. 1995. Risk-Based Concentration Table, January-June 1995.
March 7, 1995.

(b) U.S. EPA, Region IX. 1995 EPA Region IX Preliminary Remediation Goals (dated 02/01/95).

(c) U.S. EPA 1994. Comparison of EPA's First 30 Draft Generic Soil Screening Levels with States' Soil Levels. December 1994. The more conservative of the ingestion and inhalation value was chosen here.

Note:

The risk-based PRGs are purely derived using risk assumptions. Physical characteristics of the chemicals and the adsorptive limits of the soil matrix have not been incorporated into the PRG calculations. A value of 1E-09 represents a 100% concentration of the substance of interest; physically, there can be no meaning, other than, 100% concentration, to higher values.

Table 3-5 Summary of Risk-Based Soil PRGs for Direct Contact and Protective Soil Levels Based on Soil to Groundwater Migration

CHEMICAL	RISK-BASED PRGs (a)						SOIL TO GROUNDWATER MIGRATION (b)			
	ON-SITE RECEPTOR		OFF-SITE RECEPTOR				U.S. EPA MCL-Based DAF = 10	U.S. EPA Region IX PRG-Based DAF = 10	U.S. EPA Region III Soil Screening Levels DAF = 10	U.S. EPA Soil Screening Levels DAF = 10
	EXCAVATION WORKER (ug/kg)	ENVIRONMENTAL SAMPLER (ug/kg)	RESIDENT		BIKER/WALKER					
			ADULT (ug/kg)	CHILD (ug/kg)	ADULT (ug/kg)	CHILD (ug/kg)	CONCENTRATION IN SOIL (ug/kg)			
1,1,1-Trichloroethane	1.40E+09*	5.54E+09*	1.71E+07	3.66E+06	3.21E+07	6.87E+06	2825.08	18362.99	900	900
1,1-Dichloroethene	1.04E+04	2.64E+04	3.37E+01	3.61E+01	6.32E+01	6.77E+01	45.20	0.30	30	30
1,1-Dichloroethane	1.87E+09*	1.85E+10*	1.14E+07	2.43E+06	2.13E+07	4.56E+06	2113.97	2446.16	11000	11000
2-Butanone	2.62E+09*	5.54E+09*	1.60E+07	3.42E+06	3.00E+07	6.42E+06	516.71**	233.75	NL	NL
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Acetone	8.63E+09*	1.27E+12*	3.08E+07	6.60E+06	5.78E+07	1.24E+07	26.01**	22.66	8000	8000
Benzene	5.70E+05	1.09E+06	2.91E+03	3.11E+03	5.45E+03	5.84E+03	39.72	3.10	20	20
Bromodichloromethane	9.99E+06	5.76E+07	1.14E+02	1.22E+02	2.13E+02	2.28E+02	616.60	1.11	300	300
Bromoform	1.70E+07	8.03E+06	9.74E+04	1.04E+05	1.83E+05	1.96E+05	1819.70	154.67	500	500
Carbon disulfide	1.77E+07	5.43E+07	1.07E+05	2.29E+04	2.00E+05	4.28E+04	20658.46**	619.75	14000	14000
Chloroform	1.81E+05	3.93E+05	9.07E+02	9.72E+02	1.70E+03	1.82E+03	441.57	0.71	300	300
Chloromethane	9.45E+05	4.97E+06	4.82E+03	5.16E+03	9.03E+03	9.68E+03	110.77**	3.77	6.8	10
cis-1,2-Dichloroethene	4.42E+08	1.27E+11*	1.29E+06	2.76E+05	2.41E+06	5.17E+05	556.03	484.54	200	200
Dibromochloromethane	1.08E+07	4.25E+07	2.80E+03	3.00E+03	5.25E+03	5.63E+03	831.76	8.32	200	200
Ethylbenzene	2.53E+09*	5.39E+09*	1.66E+07	3.55E+06	3.11E+07	6.66E+06	12737.91	23656.11	5000	5000
m- & p Xylenes	3.94E+09*	5.61E+09*	2.38E+07	5.11E+06	4.47E+07	9.58E+06	371535.23	52014.93	230000	74000 (total)
o-Xylenes	3.35E+09*	5.61E+09*	2.00E+07	4.29E+06	3.75E+07	8.04E+06	263026.80	36823.75	150000	74000 (total)
Tetrachloroethene	5.18E+06	1.29E+07	3.71E+04	3.98E+04	6.96E+04	7.45E+04	135.82	29.88	40	40
Toluene	2.36E+09*	5.61E+09*	1.42E+07	3.05E+06	2.67E+07	5.72E+06	16218.10	11677.03	5000	5000
trans-1,2-Dichloroethene	8.84E+08	2.55E+11*	5.38E+05	1.15E+05	1.01E+06	2.16E+05	588.84	706.61	300	300
Trichloroethene	2.43E+06	5.23E+06	1.25E+04	1.34E+04	2.35E+04	2.52E+04	47.75	15.28	20	20
Vinyl chloride	4.91E+02	1.01E+05	2.47E+00	2.65E+00	4.64E+00	4.97E+00	0.49	0.005	10	10

DAF - Dilution Attenuation Factor

ND - Not determined since toxicity values not available

NL - Not Listed

PRG - Preliminary Remediation Goal

(a) The risk-based PRGs are purely derived using risk assumptions. Physical characteristics of the chemicals and the adsorptive limits of the soil matrix have not been incorporated into the PRG calculations.

Asterisks indicate theoretical results derived from mathematical manipulations but which have no physical meaning.

A value of 1E-09 represents a 100% concentration of the substance of interest; physically, there can be no meaning, other than, 100% concentration, to higher values.

(b) Sources:

U.S. EPA. 1994. Drinking Water Regulations and Health Advisories. Office of Water. November 1994.

U.S. EPA, Region III. 1995. Risk-Based Concentration Table, January-June 1995.

U.S. EPA, Region IX. 1995 EPA Region IX Preliminary Remediation Goals (dated 02/01/95).

U.S. EPA 1994. Comparison of EPA's First 30 Draft Generic Soil Screening Levels with States' Soil Levels. December 1994. The more conservative of the ingestion and inhalation value was chosen here.

** These values were derived using a non-enforceable M&E value calculated specifically for this chemical based on the methodology for calculation of a Maximum Contaminant Level Goal (MCLG) provided in the National Primary Drinking Water Regulations (Federal Register 56(20), January 30, 1991; 40 CFR Parts 141, 142, 143).

NOTE: Shading indicates the soil PRGs that appear in Table ES-1.

**TABLE 3-6
SUMMARY OF PRELIMINARY REMEDIATION GOALS**

Chemical Name	SOIL PRGs ($\mu\text{g/kg}$) ⁽¹⁾	GROUNDWATER PRGs ($\mu\text{g/L}$) ⁽²⁾
1,1,1 Trichloroethane	900	200
1,1 Dichloroethene	30	7
1,1 Dichloroethane	11,000	810 ^b
2-Butanone	517 ^a	1,900 ^b
2-Hexanone	ND	ND
Acetone	8,000	610
Benzene	20	5
Bromodichloromethane	300	100
Bromoform	500	100
Carbon Disulfide	14,000	21 ^b
Chloroform	300	100
Chloromethane	7	1.4 ^b
cis 1,2 Dichloroethene	200	70
Dibromochloromethane	200	100
Ethylbenzene	5,000	700
Xylenes	74,000	10,000
Tetrachloroethene	40	5
Toluene	5,000	1,000
trans 1,2 Dichloroethene	300	100
Trichloroethene	20	5
Vinyl Chloride	10	2

^a U.S. EPA has not derived a soil screening level for 2-butanone. Therefore, a predictive fate and transport model was used to estimate the PRG to protect groundwater. A dilution and attenuation factor of 10 is included in the model.

^b MCLs have not been developed for these compounds. Therefore, the value represents the lowest risk-based PRG for drinking water.

ND Not determined because toxicity values have not been derived for 2-hexane.

1) These summarized values are protective against chemical migration from soil to groundwater. The soil PRG is the lower value of the U.S. EPA Region III and Region IX soil screening level. If a value is not listed for either of the soil screening levels, the U.S. EPA MCL-based level is used (Table 3-5 of the text).

2) The groundwater PRG is the U.S. EPA maximum contaminant level (MCL) is not listed, then the PRG is the lower value of the U.S. EPA Region III and Region IX risk-based groundwater values (Tables 3-2 and 3-3 of the text).

TABLE 4-1
Evaluation of Established Soil Remediation Technologies
for Impacted Soils at the Granville Solvents Site
Granville, Ohio

General Response Actions	Potential Remedial Action Technologies/Description	Retained For Further Analysis?	Screening Comments	Advantages	Disadvantages
Containment	Capping - A low-permeability barrier placed over an area containing buried waste or contaminated soil. Limits surface water infiltration and subsequent migration of soil contaminants. Also reduces exposure to surface soil contaminants.	Yes	A proven technology to prevent migration of and exposure to soil contaminants.	• Low cost.	• Contaminants remain on-site; potential for future liabilities.
Removal/Disposal/Treatment	<u>Removal:</u>				
	Excavation - Use of heavy equipment and machinery to remove contaminated soils from the landfill sites.	Yes	Excavation of impacted soils followed by treatment and/or disposal is a potentially applicable remedial option.	• Contaminated soils are removed. • Treatment of excavated soils can be performed under more controlled conditions when compared with in-situ treatment remedies.	• Cost of excavation. • Potential for site workers to be exposed to soil contaminants during removal/loading of impacted soils.
	<u>Disposal:</u>				
	Off-Site Disposal at a Hazardous Waste Landfill - Disposal of treated or untreated soils at an off-site hazardous waste landfill facility.	Yes	Potentially applicable remedial action for the disposal of untreated contaminated soils at the Granville Solvents site.	• Impacted soils are permanently removed from the site.	• High cost. • Future liability for disposal, particularly if soils are not treated prior to disposal. • Land disposal restrictions may apply.
	Off-Site Disposal at a Solid Waste Landfill - Disposal of treated soils at an off-site solid waste landfill.	Yes	Potentially applicable remedial action for the disposal of soils that have been excavated and treated on-site.	• Impacted soils are permanently removed from the site. • Less costly than hazardous waste landfill disposal.	• Future liability for disposal, particularly if soils are not treated prior to disposal. • Land disposal restrictions may apply.
	On-Site Placement - Placement of treated soils on-site as fill material.	Yes	If contaminants in the soils are effectively treated to reduce future human health risks, on-site placement of the treated soils may be considered as a disposal option.	• Low cost.	• Some potential for future liabilities.
	<u>Treatment:</u>				
In-Situ Treatment	Incineration - High temperature thermal destruction of organic compounds.	No	Potentially applicable technology for treatment of organic contaminants in site soil. The public's general opposition to incineration would make this technology difficult to implement on-site. Off-site transportation and treatment costs are considered to be prohibitively high.	• Soil contaminants are permanently destroyed.	• Very high cost. • Approval of on-site treatment by nearby residents is considered unlikely.
	Soil Washing - An aqueous-based technology that, in general, uses mechanical processes to separate soil particles which contain contaminants. The contaminants can then be removed from the soil particles through solubilization in the wash water. The wash water may be augmented with a leaching agent, surfactant, pH adjustment, or chelating agent as appropriate.	No	This treatment technology is most effective when applied to soils and sediments containing large proportions of sand and gravel and is relatively ineffective when applied to soils having a high silt and clay content, as is the case the GSS soils.	• Moderate cost.	• Not technically feasible for soils with high silt and clay content.
	Bioremediation - A treatment process which provides for biological degradation of organic contaminants in soil with the aid of nutrients. Numerous treatment options (i.e., slurry-phase treatment, composting, landfarming) are included under this technology. Selection of the most appropriate treatment process is made based upon site-specific conditions and contaminants.	Yes	Technical feasibility of this technology may be limited by the high clay content of the site soils. Treatability tests should be performed to establish the anticipated effectiveness of this treatment technology.	• Low to moderate cost. • Treatment may be tailored to site-specific contaminants.	• Treatability studies are necessary to determine the effectiveness of this technology prior to implementation.
	In-Situ Bioremediation - Treatment process which provides for the biological degradation of organic contaminants in the site soils via the addition of the appropriate nutrients and/or microorganisms.	No	This technology is generally ineffective in clay-rich soils because the clay would inhibit the migration of treatment solutions, thereby limiting the technology's effectiveness.	• Soil treatment may be performed without excavation of the soil. • Low to moderate cost.	• Clay-rich soils would limit the effectiveness of this treatment technology.
	Vapor Extraction - In-situ volatilization of organic contaminants in soil through the application of a vacuum system to a centrally located extraction well or series of extraction wells in the zone of contamination. The collected gas is then treated prior to discharge.	Yes	Although on-site testing of this technology indicated that the clay-rich soil is too impervious to allow effective treatment of the site soils using vapor extraction, this technology may be appropriate when used in combination with a technology or process which increases the permeability of the site soils (e.g., hydraulic or pneumatic fracturing, horizontal drilling, etc.)	• Low cost. • Soil treatment may be performed without excavation of the soil.	• Additional study is necessary to determine if soil matrix can be altered to facilitate treatment via soil vapor extraction.

TABLE 4-2
Evaluation of Innovative Soil Remediation Technologies
for Impacted Soils at the Granville Solvents Site
Granville, Ohio

General Response Action	Potential Remedial Action Technologies/Description	Retained For Further Analysis?	Screening Comments	Advantages	Disadvantages
Treatment	<p><u>Ex-Situ Treatment:</u></p> <p>Enhanced Volatilization - Use of hammermill/pugmill equipment to mix excavated soils. The mixing action serves to volatilize the volatile organic contaminants in the soil. The volatilized contaminants can then be captured or treated, if necessary, using an appropriate control technology (e.g., carbon adsorption or oxidation units).</p> <p>Low Temperature Thermal Desorption - Low temperature heat and aeration are used to thermally strip organic compounds from contaminated soil. As with enhanced volatilization, the volatilized organic compounds may be captured or treated, if necessary, using an appropriate control technology.</p> <p><u>In-Situ Treatment:</u></p> <p>In-Situ Radio Frequency (RF) Heating - Electrodes inserted into contaminated soil through drilled boreholes to heat soil volumetrically and uniformly to temperatures between 150 C and 300 C. Heating serves to vaporize volatile and semi-volatile organic compounds which are collected with a vapor extraction and treatment system.</p> <p>In-Situ Vitrification - Use of high-intensity electric currents transferred within a square array of electrodes which have been inserted into contaminated soils. Organic contaminants are volatilized and inorganic contaminants are solidified into a stabilized vitreous block. Evolved gases containing organic contaminants are trapped under an off-gas cover for treatment.</p> <p>In-Situ Mixing/Steam Stripping - Use of a mobile drilling unit to mix and inject steam into contaminated soil. The injected steam transforms the soil-bound organic contaminants into contaminant vapors. The organic contaminant vapors migrate to the ground surface and are captured within a metal shroud under slight vacuum and treated via condensation and carbon polishing to remove the organic contaminants.</p> <p>Soil Flushing - The use of water or enhanced water solutions to facilitate the transport of soil contaminants into the groundwater. The contaminants which migrate into the groundwater would then be collected and treated with a conventional groundwater pump and treat system.</p>	<p>Yes</p> <p>Yes</p> <p>No</p> <p>No</p> <p>Yes</p> <p>Yes</p>	<p>Potentially applicable technology for the treatment of volatile organic contaminants in the site soils. The clay soils may contain strongly adsorbed organic constituents which respond unfavorably to this treatment technology. Treatability tests should be performed to evaluate the effectiveness of this technology and to assist in estimating the cost to implement this technology.</p> <p>Potentially applicable technology for the treatment of volatile organic contaminants in the site soils. The clay soils may contain strongly adsorbed organic constituents which respond unfavorably to this treatment technology. Treatability tests should be performed to evaluate the effectiveness of this technology and to assist in estimating the cost to implement this technology.</p> <p>This innovative technology is not well-proven or widely available and is not cost-effective at sites which have relatively small to moderate volumes of soil contamination.</p> <p>This innovative technology is not well-proven or widely available and is not cost-effective at sites which have relatively small to moderate volumes of soil contamination.</p> <p>This innovative technology is potentially applicable for the treatment of the organic contaminants in the site soils.</p> <p>This technology is generally ineffective in clay-rich soils because the clay would inhibit the migration of soil washing solutions, thereby limiting the technology's effectiveness. However, alteration of the site soils via pneumatic fracturing, horizontal drilling, or similar technologies designed to improve the soil permeability may result in effective soil flushing treatment.</p>	<p>* Low to moderate cost.</p> <p>* Contingent upon treatability test results, cost may be low to moderate.</p> <p>* Soil treatment may be performed without excavation of the soil.</p> <p>* Soil treatment may be performed without excavation of the soil.</p> <p>* Contingent upon treatability test results, cost may be low to moderate.</p> <p>* Soil treatment may be performed without excavation of the soil.</p> <p>* Soil treatment may be performed without excavation of the soil.</p>	<p>* Treatability testing is necessary to establish the anticipated effectiveness of this technology.</p> <p>* The high clay content of the site soils may result in poor processing performance.</p> <p>* The moisture content of the site soils may make this treatment technology cost-prohibitive.</p> <p>* Treatability testing is necessary to establish the anticipated effectiveness of this technology.</p> <p>* The high clay content of the site soils may result in poor processing performance.</p> <p>* Very high cost.</p> <p>* Technology not widely available.</p> <p>* Very high cost.</p> <p>* Technology not widely available.</p> <p>* Pockets of contaminated perched groundwater which may be present in the soils above the water table may be driven into the underlying aquifer.</p> <p>* Clay-rich soils are expected to limit the effectiveness of this treatment technology.</p> <p>* Promoting the transport of soil contaminants into the groundwater table may be considered imprudent based on regulatory considerations, the potential need for upgrading of the existing groundwater treatment system, and the close proximity of municipal water supply wells to the site.</p>

TABLE 5-1
Granville Solvents Site
Data Needs Summary

<u>Technology</u>	<u>Data Needs</u>
Biological Treatment	Bacterial Enumeration Biodegradation Confirmation Isolation of Specific Bacteria Colonies* (degrader identification) Range of Conditions Study* Hydrogeology Soil pH
Enhanced Volatilization	Moisture Content Grain Size Analysis/Particle Size Distrib. Bulk Soil Density
Hydraulic Fracturing/ SVE	Atterburg Limits Plastic Limits Liquid Limits Moisture Content
Low Temperature Thermal Desorption	Moisture Content Grain Size Analysis/Particle Size Distrib. Bulk Soil Density
In-Situ Mixing/Steam Stripping	Presence of Fractures or Perched Groundwater Total Organic Carbon Content
Soil Flushing	Grain Size Analysis/Particle Size Distrib. Bulk Soil Density

* These tests would only be performed in the event that biodegradation is confirmed.

FIGURES

nonresponsive

NOTES:

CSS-EW1 PUMPING AT 200 GPM
CSS-EW2 PUMPING AT 100 GPM
VILLAGE WELL PW-2 PUMPING AT ABOUT 750 GPM

EXPLANATION

- CONCRETE MONUMENT SET
- MONITOR WELLS
- ▲ PIEZOMETER
- EXTRACTION WELLS
- VILLAGE PRODUCTION WELLS
- OBSERVATION WELL
- HYDROPUNCH LOCATION
- BUILDING

CONTOUR INTERVAL = 0.2 FEET

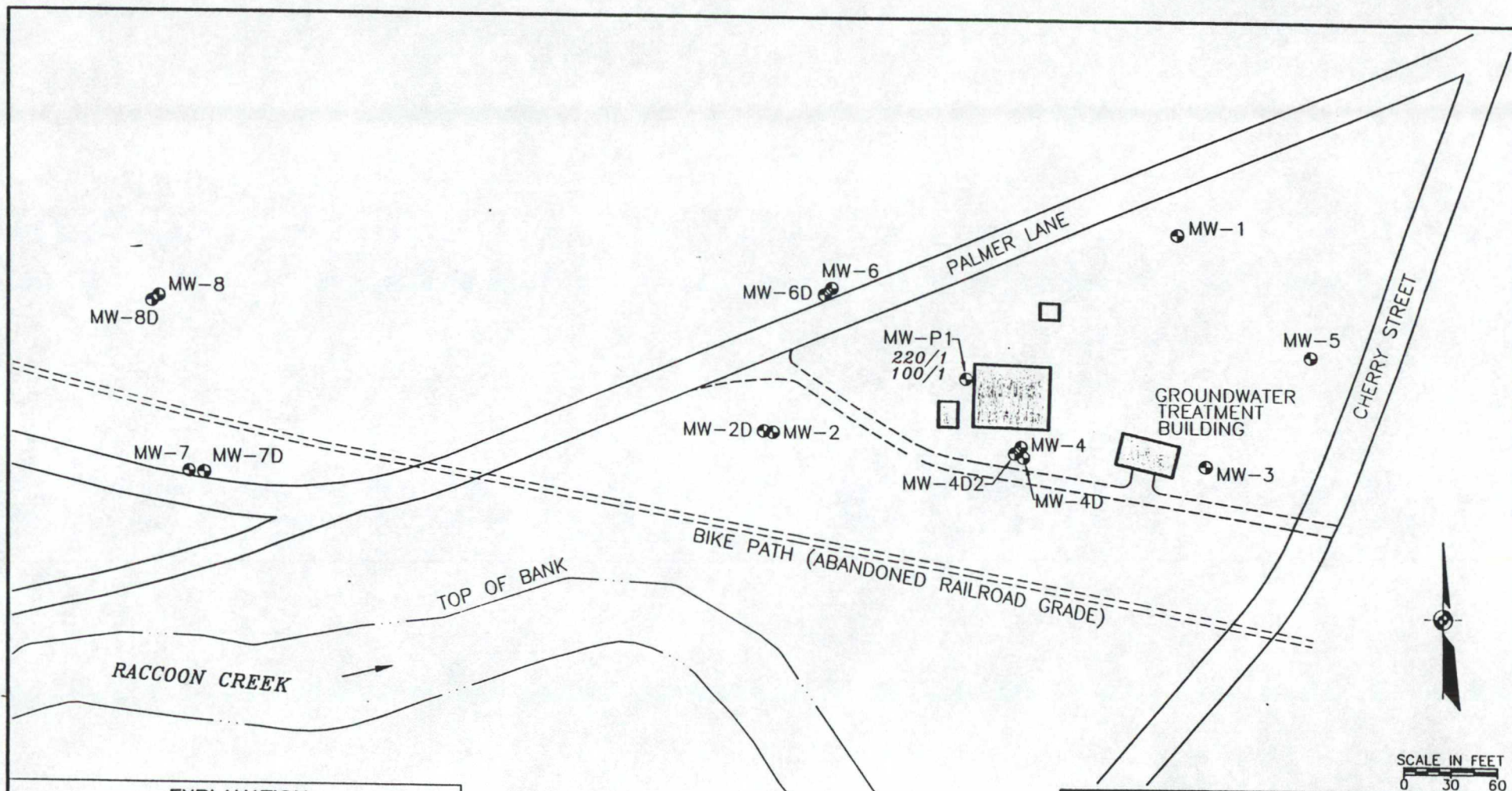
* WATER LEVEL NOT USED IN CONTOURING

SCALE IN FEET
0 45 90

M&E Metcalf & Eddy

GRANVILLE SOLVENTS SITE
GROUNDWATER POTENTIOMETRIC SURFACE MAP
JANUARY 30, 1995
GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
GRNJAN30		CAP/TPF	JUNE 95	016688	2-1



EXPLANATION



GROUNDWATER MONITORING WELL

170/11

PHOTOIONIZATION DETECTOR READING
IN ppmV (170) AT THE DEPTH
DETECTED (11)

NOTE

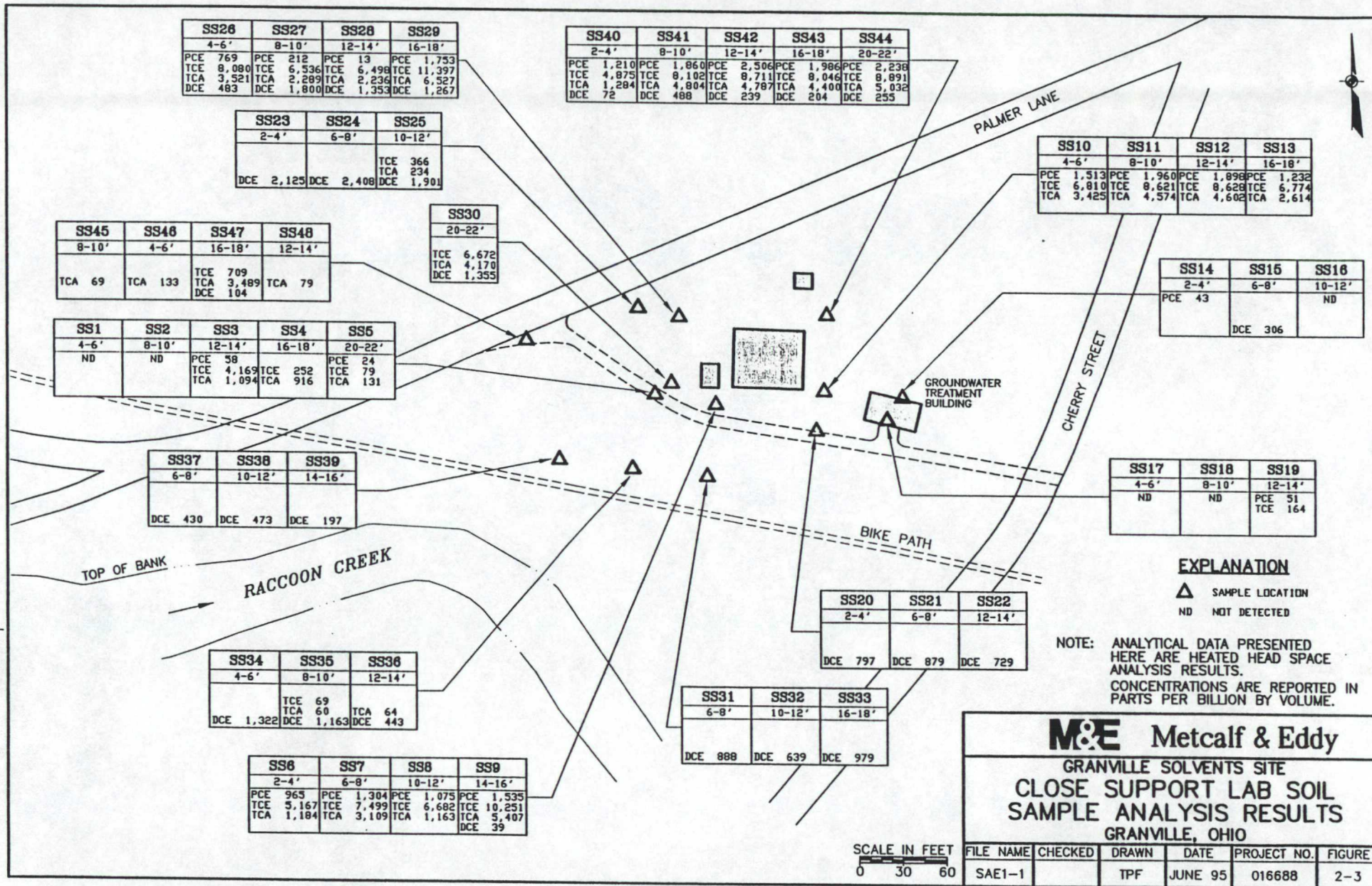
- DATA OBTAINED FROM COMPLIANCE SOLUTIONS, INC.
AUGUST 26, 1992 INTERIM ACTION REPORT.
- PID READINGS FROM SOIL COLLECTED BELOW
THE WATER TABLE ARE NOT INCLUDED.

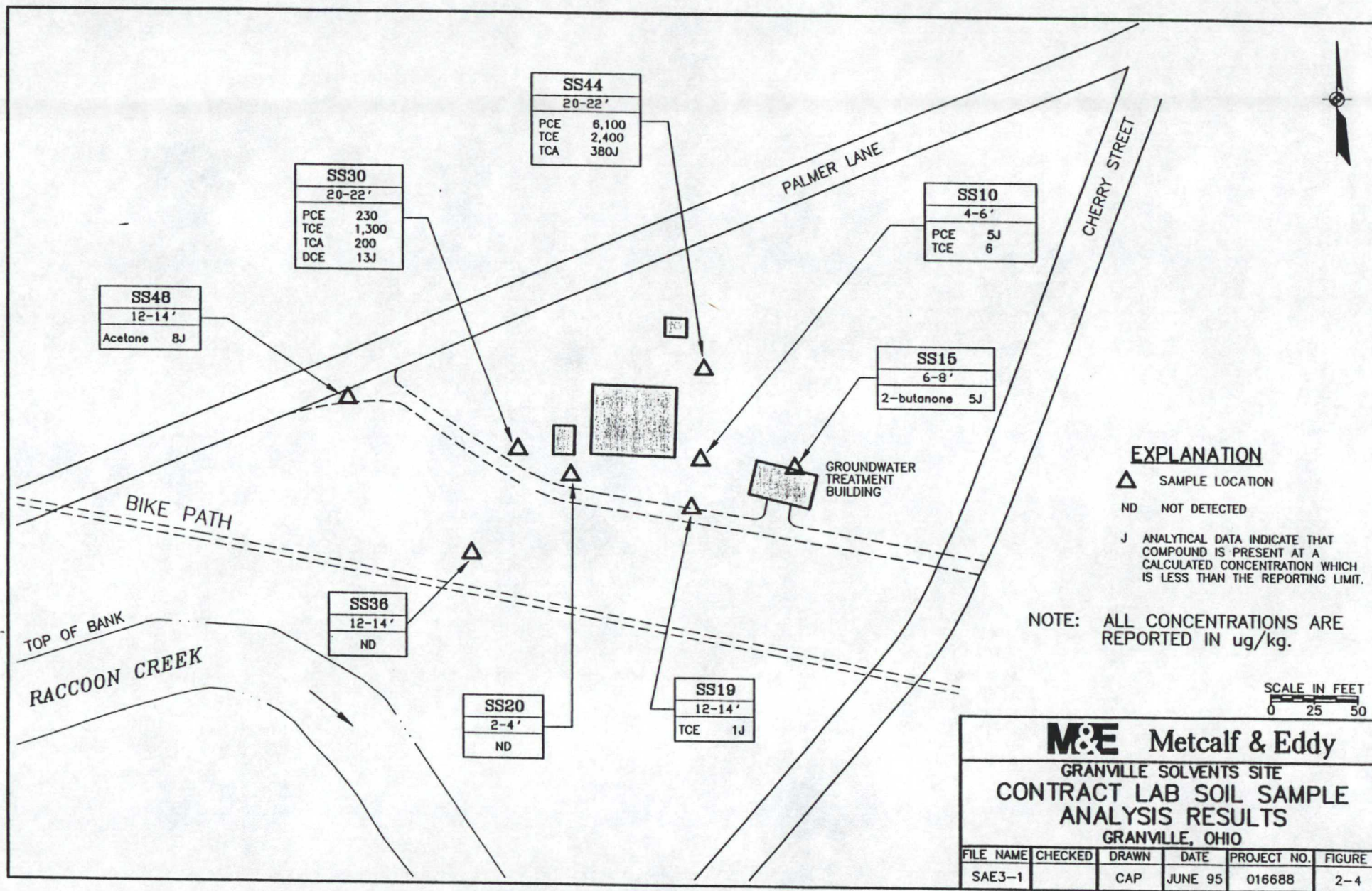
M&E Metcalf & Eddy

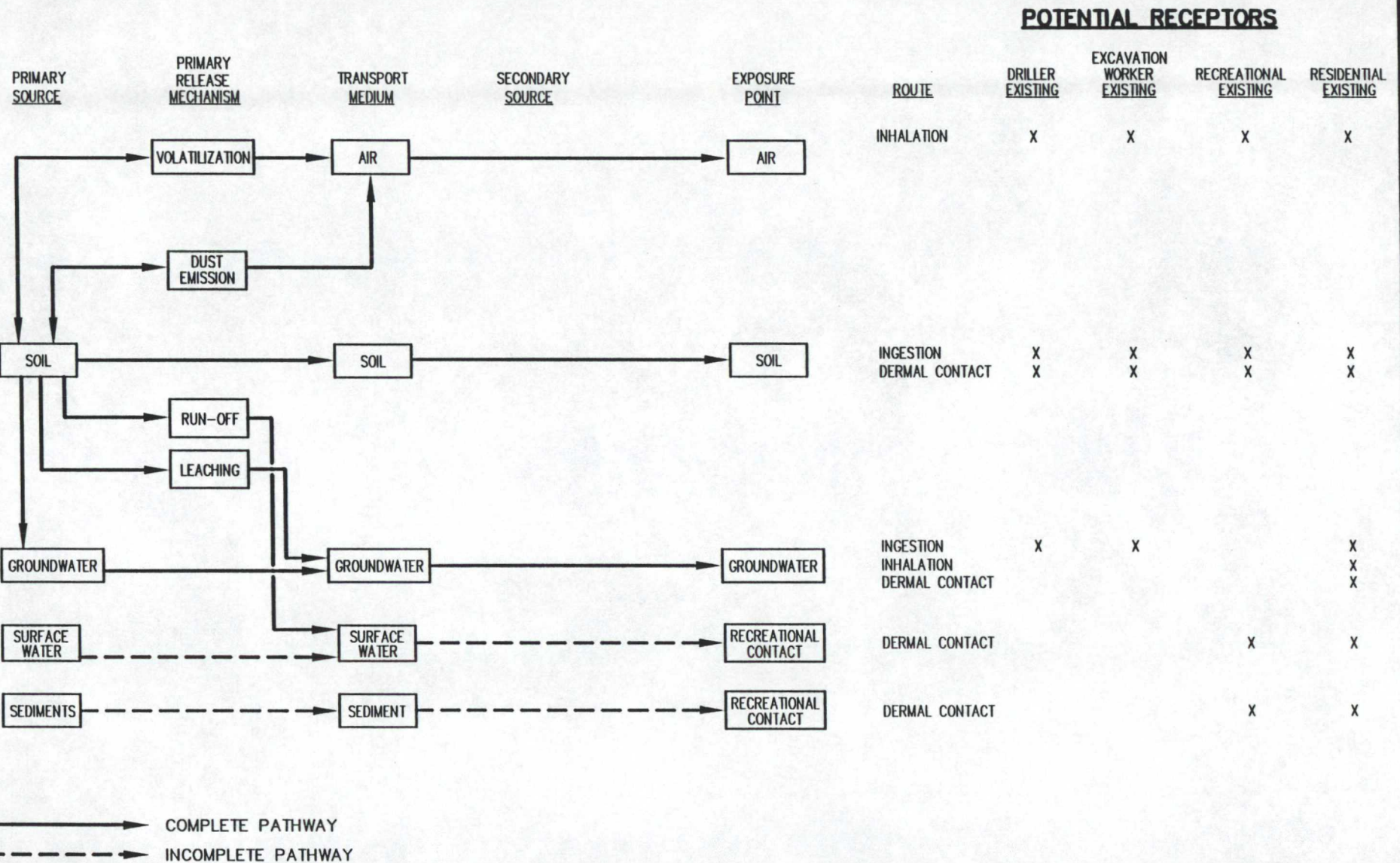
GRANVILLE SOLVENTS SITE

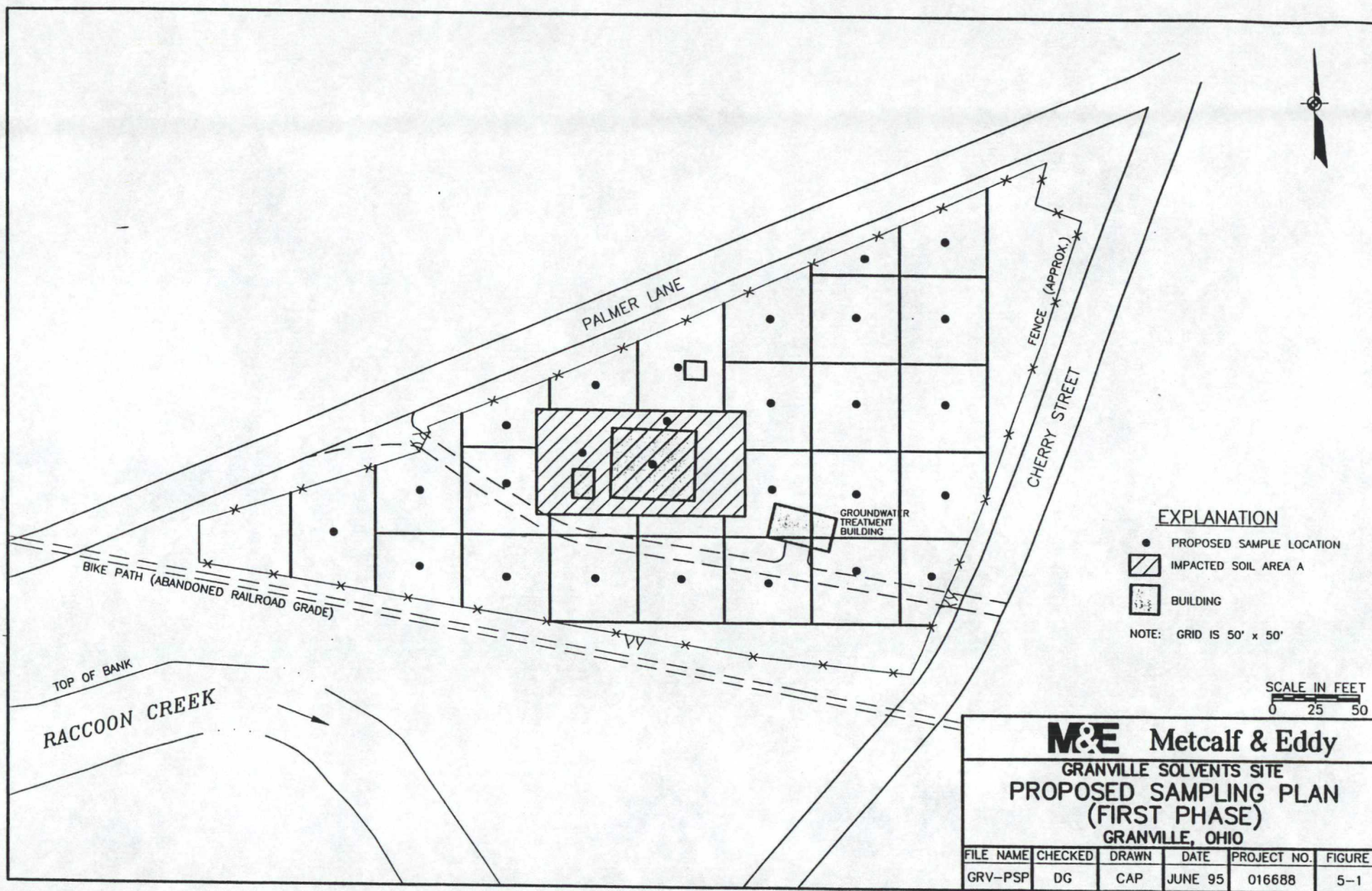
OEPA SOIL BORING LOCATIONS AND ASSOCIATED
PHOTOIONIZATION DETECTOR READINGS (MAXIMUM)
GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
16688-17		CAP	JUNE 95	016688	2-2









ATTACHMENT A

**BORING LOGS
JUNE 1991 - MAY 1992 SAMPLING INVESTIGATION**

**GRANVILLE SOLVENTS SITE
GRANVILLE, OHIO**

COMPLIANCE SOLUTIONS -- GRANVILLE PROJECT

BORING NO: 22	PAGE 1 OF 1
DATE BEGAN: 3/3/92	DATE FINISHED: 3/3/92
DRILLER: Don Heener	LOGGED BY: P. Sleet
TOP CASING MARK ELEV: 323.17	SIL. DEPTH: 25.55 FT (From top casing clay rock)
DRILLING METHOD: Hollow Stem Flight Auger, Rotary	SIL DATE/TIME: 2-17-92
NOTES: Bottom of well to top of PVC 35.25 ft	

ELEV (FT)	DEPTH (FT)	SAMPLE TYPE AND NO.	SPT BLOW PER FT	REC (ST)	METHOD	DESCRIPTION	STIC	VOLATILE ORGANIC VAPORS (ppb)						REMARKS
								03	157	250	333	417	500	
323.0	0.00					CLAYEY SILT: Brown to reddish brown, moist with gravel.	SH							
322.0	1.00													
321.0	2.00													
320.0	3.00													
319.0	4.00													
318.0	5.00													
317.0	6.00													
316.0	7.00													
315.0	8.00													
314.0	9.00													
313.0	10.00													
312.0	11.00													
311.0	12.00													
310.0	13.00													
309.0	14.00													
308.0	15.00													
307.0	16.00													
306.0	17.00													
305.0	18.00													
304.0	19.00													
303.0	20.00													
302.0	21.00													
301.0	22.00													
300.0	23.00													
299.0	24.00													
298.0	25.00													
297.0	26.00													
296.0	27.00													
295.0	28.00													
294.0	29.00													
293.0	30.00													
292.0	31.00													
291.0	32.00													
290.0	33.00													
289.0	34.00													
288.0	35.00													
287.0	36.00													
286.0	37.00													
285.0	38.00													
284.0	39.00													
283.0	40.00													
282.0	41.00													
281.0	42.00													
280.0	43.00													
279.0	44.00													
278.0	45.00													
277.0	46.00													
276.0	47.00													
275.0	48.00													
274.0	49.00													
273.0	50.00													
272.0	51.00													
271.0	52.00													
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263.0	60.00													
262.0	61.00													
261.0	62.00													
260.0	63.00													
259.0	64.00													
258.0	65.00													
257.0	66.00													
256.0	67.00													
255.0	68.00													
254.0	69.00													
253.0	70.00													

Screen depth and water level from ground at installation.

COMPLIANCE SOLUTIONS -- GRANVILLE PROJECT

BORING NO: 10-2

PAGE 1 OF 1

DATE SEDAN: 3/3/92

DATE FINISHED: 3/3/92

DRILLER: Don Heener

LOGGED BY: B. Block

TOP CASING MARK ELEV: 317.45'

BML DEPTH: 18.10 ft (from top casing elev rock)

DRILLING METHOD: Hollow Stem Flight Auger, Rotary

BML DATE/TIME: 9-17-92

NOTES: Bottom of well to top of PVC at 80 feet

DEPTH (FT)	DEPTH (FT)	SAMPLE AND NO	SPT BLOW COUNT	RET (ST)	METHOD	DESCRIPTION	STWC	VOLATILE ORGANIC VAPORS (ppb)	REMARKS
	0.00					SANDY GRAVEL: Brown, moist to wet, with clay and silt, coarse.	SW	83 167 280 333 417 500	
310.0	-5.00								
305.0	-10.00								
300.0	-15.00								
295.0	-20.00								
290.0	-25.00								
285.0	-30.00								
280.0	-35.00								
275.0	-40.00								
270.0	-45.00								
265.0	-50.00								
260.0	-55.00								
255.0	-60.00								
250.0	-65.00								
245.0	-70.00								
240.0	-75.00								
235.0	-80.00								
230.0	-85.00								
225.0	-90.00								
220.0	-95.00								
215.0	-100.00								
210.0	-105.00								
205.0	-110.00								
200.0	-115.00								
195.0	-120.00								
190.0	-125.00								
185.0	-130.00								
180.0	-135.00								
175.0	-140.00								
170.0	-145.00								
165.0	-150.00								
160.0	-155.00								
155.0	-160.00								
150.0	-165.00								
145.0	-170.00								
140.0	-175.00								
135.0	-180.00								
130.0	-185.00								
125.0	-190.00								
120.0	-195.00								
115.0	-200.00								
110.0	-205.00								
105.0	-210.00								
100.0	-215.00								
95.0	-220.00								
90.0	-225.00								
85.0	-230.00								
80.0	-235.00								
75.0	-240.00								
70.0	-245.00								
65.0	-250.00								
60.0	-255.00								
55.0	-260.00								
50.0	-265.00								
45.0	-270.00								
40.0	-275.00								
35.0	-280.00								
30.0	-285.00								
25.0	-290.00								
20.0	-295.00								
15.0	-300.00								
10.0	-305.00								
5.0	-310.00								
0.0	-315.00								

Screen depth and water level from ground at installation.

COMPLIANCE SOLUTIONS -- GRANVILLE PROJECT

BORING NO: 50

PAGE 1 OF 1

DATE BEGAN: 3/5/92

DATE FINISHED: 3/5/92

DRILLER: Don Heener

LOGGED BY: D. Kreitzburg

TOP CASING MARK ELEV: 338.85'

BWL DEPTH: 38.35 ft (from top casing elev mark)

DRILLING METHOD: Hollow Stem Flight Auger, Rotary

BWL DATE/TIME: 9-17-92

NOTES: Bottom of well from top of PVC 55.13 feet

ELEV (FT)	DEPTH (FT)	SAMPLE TYPE AND NO.	SPT BLOWS PER FT	REF (FT)	METHOD	DESCRIPTION	STAGE	VOLATILE ORGANIC VAPORS (ppb)	REMARKS
								02 167 250 333 417 599	
	0.00					CLAYEY SILT: Brown, moist, trace gravel. Top 9" crushed stone and organic top soil.	1		
330.0	-5.00	1							
325.0	-10.00					SILTY SAND: Brown, moist, with gravel and some clay.	2		
320.0	-15.00	2							
315.0	-20.00					SANDY GRAVEL: Brown, moist to wet, med. cobble.	3		
310.0	-25.00	3							
305.0	-30.00								
300.0	-35.00	4							
295.0	-40.00								
290.0	-45.00								
285.0	-50.00								
280.0	-55.00	5	55	60		SAND: Brown, wet, coarse, with gravel and trace silt.	4		
275.0	-60.00	6	55	60					
270.0	-65.00	7	57	60		GRAVEL: Brown, wet, well sorted, some sand and silt, .5 inch well rounded gravel.	5		
265.0	-70.00	8	45	70					
260.0	-75.00	9	54	70		SAND: Brown, wet, trace gravel, few black silt bits.	6		
255.0	-80.00	10	54	60					
250.0	-85.00	11	38	60					
245.0	-90.00	12	45	60		SAND: Dark brown, wet, with gravel, trace silt.	7		
240.0	-95.00	13	59	60					
235.0	-100.00	14	59	70					
230.0	-105.00								
225.0	-110.00								
220.0	-115.00								
215.0	-120.00								
210.0	-125.00								
205.0	-130.00								
200.0	-135.00								
195.0	-140.00								
190.0	-145.00								
185.0	-150.00								
180.0	-155.00								
175.0	-160.00								
170.0	-165.00								
165.0	-170.00								
160.0	-175.00								
155.0	-180.00								
150.0	-185.00								
145.0	-190.00								
140.0	-195.00								
135.0	-200.00								
130.0	-205.00								
125.0	-210.00								
120.0	-215.00								
115.0	-220.00								
110.0	-225.00								
105.0	-230.00								
100.0	-235.00								
95.0	-240.00								
90.0	-245.00								
85.0	-250.00								
80.0	-255.00								
75.0	-260.00								
70.0	-265.00								
65.0	-270.00								
60.0	-275.00								
55.0	-280.00								
50.0	-285.00								
45.0	-290.00								
40.0	-295.00								
35.0	-300.00								
30.0	-305.00								
25.0	-310.00								
20.0	-315.00								
15.0	-320.00								
10.0	-325.00								
5.0	-330.00								
0.0	-335.00								

Screen depth and water level from ground at installation

34.5

34.5

COMPLIANCE SOLUTIONS -- GRANVILLE PROJECT

BORING NO. 2

1 OF 1

DATE BEGAN: 3/7/92

DATE FINISHED: 3/7/92

DRILLER: Don Heaner

LOGGED BY: D. Kreitzburg

TOP CASING MARK ELEV: 928.8'

BWL DEPTH: 30.72 FT (from top casing elev mark)

DRILLING METHOD: Hollow Stem Flight Auger, Rotary

BWL DATE/TIME: 2-17-92

NOTES: Bottom of well to top of PVC 38.40 feet

ELEV (FT)	DEPTH (FT)	SAMPLE TYPE AND NO.	SPT BLows per FT	RET 1/2" 1/2"	REMARKS	STAC	VOLATILE ORGANIC VAPORS (ppb)	REMARKS
							83 167 250 333 417 500	
925.0	0.00		18	88	CLAYEY SILT: Brown, moist, some organics.	7		
			80	100				
920.0	-5.00		80	100	SILTY CLAY: Light brown, moist, with fine gravel, some reddish clay bits.	8		
			48	100				
			44	100				
915.0	-10.00		84	8	SILT: Brown, moist, with gravel, occ. cobbles, some iron stains.	9		
			38	80				
			38	8				
910.0	-15.00		88	4	GRAVELLY SAND: Light brown to tan, dry, many cobbles, some iron stains.	10		
			48	80				
905.0	-20.00		44	70	GRAVELLY SAND: Light brown to tan, dry, trace clay and organics, some iron stains.	11		
			86	70				
900.0	-25.00		83	80				
			48	70	SILTY SAND: Brown, moist to wet, with gravel.	12		
			44	80				
895.0	-30.00		88	4				
			88	8				
890.0	-35.00		88	8	GRAVELLY SAND: Dark brown, wet, with gravel and silty coarse sand.	13		
			88	80				
885.0	-40.00							
880.0	-45.00							
875.0	-50.00							
870.0	-55.00							
865.0	-60.00							
860.0	-65.00							
855.0	-70.00							

Screen closed
and water
level free
ground at
installation

COMPLIANCE SOLUTIONS -- GRANVILLE PROJECT

BORING NO: 50	PAGE 1 OF 1
DATE BEGAN: 2/7/92	DATE FINISHED: 2/7/92
DRILLER: Don Heener	LOGGED BY: D. Kreitzberg
TOP CASING MARK ELEV: 328.32'	BWL DEPTH: 30.9 Ft (From top casing elev mark)
DRILLING METHOD: Hollow Stem Flight Auger, Rotary	BWL DATE/TIME: 2-17-92

NOTES: Bottom of well to top of PVC 33.4'

ELEV (FT)	DEPTH (FT)	SAMPLE TYPE AND NO.	SPT BLows per ft	RET 1ST	FITTINGS	DESCRIPTION	REMARKS	VOLATILE ORGANIC VAPORS (ppb)						REMARKS
								03	151	250	329	417	500	
325.0	0.0					CLAYEY SILT: Brown, moist, some gravel.								
320.0	5.0													
315.0	10.0					GRAVELY SAND: Brown, moist to wet, with silt and some clay.								
310.0	15.0													
305.0	20.0													
300.0	25.0													
295.0	30.0													
290.0	35.0													
285.0	40.0													
280.0	45.0													
275.0	50.0													
270.0	55.0													
265.0	60.0													
260.0	65.0													
255.0	70.0													
250.0	75.0													
245.0	80.0													
240.0	85.0													
235.0	90.0													
230.0	95.0													
225.0	100.0													
220.0	105.0													
215.0	110.0													
210.0	115.0													
205.0	120.0													
200.0	125.0													
195.0	130.0													
190.0	135.0													
185.0	140.0													
180.0	145.0													
175.0	150.0													
170.0	155.0													
165.0	160.0													
160.0	165.0													
155.0	170.0													
150.0	175.0													
145.0	180.0													
140.0	185.0													
135.0	190.0													
130.0	195.0													
125.0	200.0													
120.0	205.0													
115.0	210.0													
110.0	215.0													
105.0	220.0													
100.0	225.0													

Screen depth
and water
level from
ground at
installation

[illegible]

[illegible]

SWL DATE/TIME: At completion

[illegible]

PAGE 1 OF 1
DATE FINISHED: 6/28/91
LOGGED BY: D. MEHN
GWL DEPTH: 17.5 Ft
GWL DATE/TIME: At completion

[illegible]

PAGE 1 OF 1
DATE FINISHED: _____
LOGGED BY: D. HEIN _____
SIL DEPTH: 18 Ft _____
SIL DATE/TIME: At completion _____

[illegible]

APPENDIX A

**PRELIMINARY REMEDIATION GOALS
FOR CHEMICALS OF POTENTIAL CONCERN
IN SOIL**

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1.0 DEVELOPMENT OF RISK-BASED PRELIMINARY REMEDIATION GOALS

This appendix describes the methods by which human health risk-based preliminary remediation goals (PRGs) were developed for the Granville Solvents Site (GSS). Guidance for the determination of the PRGs was based on the U.S. EPA's Human Health Evaluation Manual (HHEM), Part B: "Development of Risk-Based Preliminary Remediation Goals" (U.S. EPA, 1991, U.S. EPA, 1992). As outlined in the U.S. EPA guidance, risk-based PRGs are calculated in order to reflect the potential risk from exposure to a chemical, given a specific pathway, medium, and land-use combination. The PRGs (for direct contact with chemicals in soil and for the protection against chemical migration from soil to groundwater) were developed for the list of chemicals detected at the GSS in soil and/or groundwater. The GSS is not currently active. However, areas in the vicinity of the site are used for commercial and residential purposes. Potential receptors and specific pathways of exposures considered for the GSS are as follows:

- 1) On-Site Environmental Sampler
 - Soil ingestion
 - Inhalation of volatiles/particulates from soil
- 2) On-Site Excavation Worker
 - Soil ingestion
 - Inhalation of volatiles/particulates from soil
- 3) Off-Site Residential Adult
 - Inhalation of volatiles/particulates from soil
- 4) Off-Site Residential Child
 - Inhalation of volatiles/particulates from soil
- 5) Off-Site Adult Biker/Walker
 - Inhalation of volatiles/particulates from soil
- 6) Off-Site Child Biker/Walker
 - Inhalation of volatiles/particulates from soil

Based on the currently available information for the GSS, potential exposures to chemicals in soil (via incidental ingestion and/or inhalation of volatiles/particulates) could reasonably be expected to occur. The degree of such soil exposure would likely differ among the various receptors. However, exposure to groundwater is not expected to occur for the potential receptors identified for the site. Therefore, only site-specific PRGs for exposure to soil are developed in this Appendix. The use of the six potential receptors listed above in the calculation of soil PRGs provides a range of levels that may assist in the selection of remedial alternatives for the GSS. Tables 1 through 6 provide the chemical-specific soil PRGs for the identified receptors. Overall, the goal for the level of health protection for each of the receptor groups is the same, but the degree of exposure (i.e., duration, frequency, pathway of exposure, etc.) varies. The end result is that the PRGs are receptor-specific. In the case where one receptor is exposed less frequently or by fewer pathways (i.e., inhalation, ingestion, etc.), the risk-based PRG will be higher than for another receptor who has occasion for more frequent or multi-pathway exposures.

The PRGs are derived from calculations in which the acceptable criteria for cancer risk and noncancer hazard ($1E-06$ and 1.0 , respectively) are utilized to quantify the risk-based concentration of each chemical of concern. The objective is to determine the chemical concentration which will not result in an exceedance of the risk criteria. Calculation of the PRGs is based on the toxicity characteristic of the chemical and the receptor-specific exposure assumptions for each land-use scenario. The PRG equations utilized for the GSS are based on site-specific exposure information (when available), and U.S. EPA standard default exposure assumptions (U.S. EPA, 1991). Toxicity values for the chemicals of concern have been provided in the soil PRG tables (Tables 1 through 6). The soil PRGs were based primarily on oral and/or inhalation exposures. The cleanup goals were calculated on an exposure-specific and a chemical-specific basis. Tables 7 through 19 provide the equations and the assumptions utilized for the parameter values in the calculation of the human health soil cleanup goals.

2.0 DEVELOPMENT OF RISK-BASED PRGS FOR SOIL TO GROUNDWATER MIGRATION

The chemical concentrations in soil which will result in groundwater chemical concentrations that do not exceed a health protective criterion [i.e., a maximum contaminant level (MCL) or risk-based groundwater PRG] were derived for the GSS. These PRGs were derived based on the use of a predictive fate and transport model to characterize the potential for soil to groundwater migration of chemicals. Such models were employed to estimate the relationship between soil and groundwater chemical concentrations.

Chemical-specific PRGs were then derived once the relationship between soil and groundwater chemical concentrations was predicted.

Selection of an appropriate fate and transport model is dependent upon the availability of site-specific information. For the purposes of this document, a simple, conservative relationship between the site organic carbon content and organic carbon coefficient (K_{oc}) was selected to estimate soil to groundwater migration of chemicals. This approach does not provide a definitive, in-depth analysis of the complex fate and transport processes of chemicals in the subsurface environment. Therefore, a number of chemical and physical factors (including dilution, attenuation, biodegradation, etc.) are not considered in the model.

The technique used to predict groundwater concentrations which hypothetically could result from concentrations in soil is based on the soil adsorption coefficient (or distribution coefficient) K_d . The K_d is defined as the ratio of the concentration adsorbed on soil surfaces to the concentration in water (Dragun 1988). The K_d model assumes that the liquid and solid phases are at equilibrium and that there is a linear relationship between solute concentrations in the liquid and solid phases. The greater the extent of adsorption, the greater the magnitude of the K_d .

The application of K_d to soil-water phase systems is subject to the following assumptions:

- The water travels through uniformly porous media.
- A rapid and reversible chemical equilibrium exists between groundwater and soils.

The K_d value for organic constituents was determined using the following equation (Karickhoff, 1979):

$$K_d = 0.63 (f_{oc} * K_{ow}) \quad (1)$$

where:

K_d = Chemical-specific adsorption coefficient, l/kg

f_{oc} = Fraction organic carbon content (0.01, based on an average total organic matter of 2% for the types of soil present at the GSS. Ohio Department of Natural Resources, Soil Survey of Licking County, May 1992). The fraction organic content is determined by dividing the total organic matter value by 1.724.

K_{ow} = Chemical-specific octanol water partition coefficient, l/kg (estimated experimentally as provided in Howard, 1989, 1990)

0.63 = Empirical constant.

The K_d can then be used to determine the partitioning of a chemical between the soil and water phase. Thus, groundwater chemical concentrations are predicted based on the K_d and the chemical concentration in soil. The following equation is taken from the EPA document "Determining Soil Response Action Levels Based on Potential Contaminant Migration to Groundwater" (U.S. EPA, 1980):

$$C_{water} = C_{soil}/K_d \quad (2)$$

where:

C_{water} = Concentration in water, mg/l

K_d = Absorption coefficient, l/kg

C_{soil} = Maximum concentration in soil, mg/kg

or:

$$C_{soil} = C_{water} \times K_d \quad (3)$$

To determine the soil PRG (C_{soil}), the equation is rearranged to solve for C_{soil} , and C_{water} is set equal to a drinking water standard, such as an MCL or risk-based action level. Thus, the equation is as follows:

$$PRG_{soil} = MCL(\text{or Risk-Based Action Level}) \times K_d \quad (4)$$

For comparison purposes, both the chemical-specific MCL and Risk Based Action Levels developed by U.S. EPA Region IX, were utilized to derive a protective soil concentration using equation (4). The estimates of the soil concentrations are provided in Tables 20 and 21.

REFERENCES

- U.S. EPA. 1991. U.S. Environmental Protection Agency. Human Health Evaluation Manual Part B: "Development of Risk-Based Preliminary Remediation Goals." OSWER Directive 9285.7-01B. December 13, 1991.
- U.S. EPA. 1992. Memo from Janine Dinan. Changes to Equations in the Part B Guidance. November 9, 1992.
- Howard, P.H. 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I. Lewis Publishers, Inc., Michigan.
- Howard, P.H. 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II. Lewis Publishers, Inc., Michigan.
- PADR. 1990. Pennsylvania Department of Environmental Resources, Bureau of Waste Management. User's Manual For Risk Assessment/Fate and Transport (RAFT) Modeling System Version 1.0. July 1990.

Table A-1 Risk-Based Preliminary Remediation Goals (PRGs) for an Excavation Worker for Chemicals of Concern in Soil at Granville Solvents

CHEMICAL	TOXICITY INFORMATION*				PRGs	
	CARCINOGENIC		NONCARCINOGENIC**		ORAL AND INHALATION EXPOSURE	
	SF oral per (mg/kg/day)	SF inh per (mg/kg/day)	RfD oral (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	NA	NA	3.00E-01	ND	1.40E+06
1,1-Dichloroethane	NA	NA	1.00E+00	1.00E+00	ND	1.87E+06
1,1-Dichloroethene	6.00E-01	1.20E+00	9.00E-03	NA	1.04E+01	2.57E+04
2-Butanone	NA	NA	6.00E-01	3.00E-01	ND	2.62E+06
2-Hexanone	NA	NA	NA	NA	ND	ND
Acetone	NA	NA	1.00E+00	NA	ND	8.63E+06
Benzene	2.90E-02	2.90E-02	NA	NA	5.70E+02	ND
Bromodichloromethane	6.20E-02	NA	2.00E-02	NA	1.46E+04	9.99E+03
Bromoform	7.90E-03	3.90E-03	2.00E-01	NA	1.70E+04	5.12E+06
Carbon disulfide	NA	NA	1.00E-01	2.90E-03	ND	1.77E+04
Chloroform	6.10E-03	8.10E-02	1.00E-02	NA	1.81E+02	5.15E+04
Chloromethane	1.30E-02	6.30E-03	NA	NA	9.45E+02	ND
cis-1,2-Dichloroethene	NA	NA	1.00E-01	NA	ND	4.42E+05
Dibromochloromethane	8.40E-02	NA	2.00E-01	NA	1.08E+04	3.19E+06
Ethylbenzene	NA	NA	1.00E-01	3.00E-01	ND	2.53E+06
m- & p Xylenes	NA	NA	2.00E+00	3.00E-01	ND	3.94E+06
o-Xylenes	NA	NA	2.00E+00	3.00E-01	ND	3.34E+06
Tetrachloroethene	5.20E-02	2.00E-03	1.00E-01	NA	5.18E+03	5.19E+05
Toluene	NA	NA	2.00E+00	3.00E-01	ND	2.36E+06
trans-1,2-Dichloroethene	NA	NA	2.00E-01	NA	ND	8.84E+05
Trichloroethene	1.10E-02	6.00E-03	NA	NA	2.43E+03	ND
Vinyl chloride	1.90E+00	3.00E-01	NA	NA	4.91E-01	ND

NA - Not Available

ND - Not Determined

SF oral - Slope Factor-oral exposure

SF inh - Slope Factor-Inhalation exposure

RfD oral - Reference Dose-oral exposure

RfD inh - Reference Dose-Inhalation exposure

* Toxicity Information Sources: Integrated Risk Information System (IRIS, Accessed 4/5/95); and Health Effects Assessment Summary Tables (1994)

** Noncarcinogenic toxicity values are subchronic because exposure duration is less than seven years.

Note: Oral toxicity values were also used for Inhalation toxicity values in the PRG calculation when Inhalation toxicity values were not available (route-to-route extrapolation)

Table A-2 Risk-Based Preliminary Remediation Goals (PRGs) for an Environmental Sampler for Chemicals of Concern in Soil at Granville Solvents

CHEMICAL	TOXICITY INFORMATION*				PRGs	
	CARCINOGENIC		NONCARCINOGENIC**		ORAL AND INHALATION EXPOSURE	
	SF oral per (mg/kg/day)	SF inh per (mg/kg/day)	RfD oral (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	NA	NA	3.00E-01	ND	5.54E+06
1,1-Dichloroethane	NA	NA	1.00E+00	1.00E+00	ND	1.85E+07
1,1-Dichloroethene	6.00E-01	1.20E+00	9.00E-03	NA	2.64E+01	1.15E+07
2-Butanone	NA	NA	6.00E-01	3.00E-01	ND	5.54E+06
2-Hexanone	NA	NA	NA	NA	ND	ND
Acetone	NA	NA	1.00E+00	NA	ND	1.27E+09
Benzene	2.90E-02	2.90E-02	NA	NA	1.09E+03	ND
Bromodichloromethane	6.20E-02	NA	2.00E-02	NA	5.76E+04	2.55E+07
Bromoform	7.90E-03	3.90E-03	2.00E-01	NA	8.03E+03	2.55E+08
Carbon disulfide	NA	NA	1.00E-01	2.90E-03	ND	5.43E+04
Chloroform	6.10E-03	8.10E-02	1.00E-02	NA	3.93E+02	1.27E+07
Chloromethane	1.30E-02	6.30E-03	NA	NA	4.97E+03	ND
cis-1,2-Dichloroethene	NA	NA	1.00E-01	NA	ND	1.27E+08
Dibromochloromethane	8.40E-02	NA	2.00E-01	NA	4.25E+04	2.55E+08
Ethylbenzene	NA	NA	1.00E-01	3.00E-01	ND	5.39E+06
m- & p Xylenes	NA	NA	2.00E+00	3.00E-01	ND	5.61E+06
o-Xylenes	NA	NA	2.00E+00	3.00E-01	ND	5.61E+06
Tetrachloroethene	5.20E-02	2.00E-03	1.00E-01	NA	1.29E+04	1.27E+08
Toluene	NA	NA	2.00E+00	3.00E-01	ND	5.61E+06
trans-1,2-Dichloroethene	NA	NA	2.00E-01	NA	ND	2.55E+08
Trichloroethene	1.10E-02	6.00E-03	NA	NA	5.23E+03	ND
Vinyl chloride	1.90E+00	3.00E-01	NA	NA	1.01E+02	ND

NA - Not Available

ND - Not Determined

SF oral - Slope Factor-oral exposure

SF inh - Slope Factor-inhalation exposure

RfD oral - Reference Dose-oral exposure

RfD inh - Reference Dose-inhalation exposure

* Toxicity Information Sources: Integrated Risk Information System (IRIS, Accessed 4/5/95); and Health Effects Assessment Summary Tables (1994)

** Noncarcinogenic toxicity values are subchronic because exposure duration is less than seven years.

Note: Oral toxicity values were also used for inhalation toxicity values in the PRG calculation when inhalation toxicity values were not available (route-to-route extrapolation)

Table A-3 Risk-Based Soil Preliminary Remediation Goals (PRGs) for an Adult Residential Scenario – Inhalation Pathway

CHEMICAL	Toxicity Information**		PRGs	
	Carcinogenic	Noncarcinogenic*	Inhalation Exposure	
	SF inh per (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	6.0E-01	ND	1.71E+04
1,1-Dichloroethene	1.2E+00	NA	3.37E-02	ND
1,1-Dichloroethane	NA	1.0E+00	ND	1.14E+04
2-Butanone	NA	3.0E-01	ND	1.60E+04
2-Hexanone	NA	NA	ND	ND
Acetone	NA	1.0E+00	ND	3.08E+04
Benzene	2.9E-02	NA	2.91E+00	ND
Bromodichloromethane	6.2E-02	2.0E-02	1.14E-01	6.04E+01
Bromoform	3.9E-03	NA	9.74E+01	ND
Carbon disulfide	NA	2.9E-03	ND	1.07E+02
Chloroform	8.1E-02	NA	9.07E-01	ND
Chloromethane	6.3E-03	NA	4.82E+00	ND
cis-1,2-Dichloroethene	NA	1.0E-01	ND	1.29E+03
Dibromochloromethane	8.4E-02	2.0E-01	2.80E+00	2.02E+04
Ethylbenzene	NA	3.0E-01	ND	1.66E+04
m- & p Xylenes	NA	3.0E-01	ND	2.38E+04
o-Xylenes	NA	3.0E-01	ND	2.00E+04
Tetrachloroethene	2.0E-03	NA	3.71E+01	ND
Toluene	NA	3.0E-01	ND	1.42E+04
trans-1,2-Dichloroethene	NA	2.0E-02	ND	5.38E+02
Trichloroethene	6.0E-03	NA	1.25E+01	ND
Vinyl chloride	3.0E-01	NA	2.47E-03	ND

NA – Not available

ND – Not Determined

SF inh – Slope Factor – inhalation exposure

RfD inh – Reference Dose – inhalation exposure

** Toxicity Information Sources: Integrated Risk Information System (IRIS), Accessed April 1995; and
Health Effects Assessment Summary Tables (1994).

* RfD inhalation values are subchronic where a subchronic value existed. Chronic values were used if no subchronic values existed.

Shading indicates that a route-to-route extrapolation was used where no toxicity values existed.

Table A-4 Risk-Based Soil Preliminary Remediation Goals (PRGs) for a Child Residential Scenario – Inhalation Pathway

CHEMICAL	Toxicity Information**		PRGs	
	Carcinogenic	Noncarcinogenic*	Inhalation Exposure	
	SF inh per (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	6.0E-01	ND	3.66E+03
1,1-Dichloroethene	1.2E+00	NA	3.61E-02	ND
1,1-Dichloroethane	NA	1.0E+00	ND	2.43E+03
2-Butanone	NA	3.0E-01	ND	3.42E+03
2-Hexanone	NA	NA	ND	ND
Acetone	NA	1.0E+00	ND	6.60E+03
Benzene	2.9E-02	NA	3.11E+00	ND
Bromodichloromethane	6.2E-02	2.0E-02	1.22E-01	1.29E+01
Bromoform	3.9E-03	NA	1.04E+02	ND
Carbon disulfide	NA	2.9E-03	ND	2.29E+01
Chloroform	8.1E-02	NA	9.72E-01	ND
Chloromethane	6.3E-03	NA	5.16E+00	ND
cis-1,2-Dichloroethene	NA	1.0E-01	ND	2.76E+02
Dibromochloromethane	8.4E-02	2.0E-01	3.00E+00	4.32E+03
Ethylbenzene	NA	3.0E-01	ND	3.55E+03
m- & p Xylenes	NA	3.0E-01	ND	5.11E+03
o-Xylenes	NA	3.0E-01	ND	4.29E+03
Tetrachloroethene	2.0E-03	NA	3.98E+01	ND
Toluene	NA	3.0E-01	ND	3.05E+03
trans-1,2-Dichloroethene	NA	2.0E-02	ND	1.15E+02
Trichloroethene	6.0E-03	NA	1.34E+01	ND
Vinyl chloride	3.0E-01	NA	2.65E-03	ND

NA – Not available

ND – Not Determined

SF inh – Slope Factor – inhalation exposure

RfD inh – Reference Dose – inhalation exposure

** Toxicity Information Sources: Integrated Risk Information System (IRIS), Accessed April 1995; and
Health Effects Assessment Summary Tables (1994).

* RfD inhalation values are subchronic where a subchronic value existed. Chronic values were used if no subchronic values existed.

Shading indicates that a route-to-route extrapolation was used where no toxicity values existed.

Table A-5 Risk-Based Soil Preliminary Remediation Goals (PRGs) for an Adult Biker/Walker Scenario – Inhalation Pathway

CHEMICAL	Toxicity Information**		PRGs	
	Carcinogenic	Noncarcinogenic*	Inhalation Exposure	
	SF inh per (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	6.0E-01	ND	3.21E+04
1,1-Dichloroethene	1.2E+00	NA	6.32E-02	ND
1,1-Dichloroethane	NA	1.0E+00	ND	2.13E+04
2-Butanone	NA	3.0E-01	ND	3.00E+04
2-Hexanone	NA	NA	ND	ND
Acetone	NA	1.0E+00	ND	5.78E+04
Benzene	2.9E-02	NA	5.45E+00	ND
Bromodichloromethane	6.2E-02	2.0E-02	2.13E-01	1.13E+02
Bromoform	3.9E-03	NA	1.83E+02	ND
Carbon disulfide	NA	2.9E-03	ND	2.00E+02
Chloroform	8.1E-02	NA	1.70E+00	ND
Chloromethane	6.3E-03	NA	9.03E+00	ND
cis-1,2-Dichloroethene	NA	1.0E-01	ND	2.41E+03
Dibromochloromethane	6.4E-02	2.0E-01	5.25E+00	3.78E+04
Ethylbenzene	NA	3.0E-01	ND	3.11E+04
m- & p Xylenes	NA	3.0E-01	ND	4.47E+04
o-Xylenes	NA	3.0E-01	ND	3.75E+04
Tetrachloroethene	2.0E-03	NA	6.96E+01	ND
Toluene	NA	3.0E-01	ND	2.67E+04
trans-1,2-Dichloroethene	NA	2.0E-02	ND	1.01E+03
Trichloroethene	6.0E-03	NA	2.35E+01	ND
Vinyl chloride	3.0E-01	NA	4.64E-03	ND

NA – Not available

ND – Not Determined

SF inh – Slope Factor – inhalation exposure

RfD inh – Reference Dose – inhalation exposure

** Toxicity Information Sources: Integrated Risk Information System (IRIS), Accessed April 1995; and
Health Effects Assessment Summary Tables (1994).

* RfD inhalation values are subchronic where a subchronic value existed. Chronic values were used if no subchronic values existed.

Shading indicates that a route-to-route extrapolation was used where no toxicity values existed.

Table A-6 Risk-Based Soil Preliminary Remediation Goals for a Child Biker/Walker Scenario – Inhalation Pathway

CHEMICAL	Toxicity Information**		PRGs	
	Carcinogenic	Noncarcinogenic*	Inhalation Exposure	
	SF inh per (mg/kg/day)	RfD inh (mg/kg/day)	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)
1,1,1-Trichloroethane	NA	6.0E-01	ND	6.87E+03
1,1-Dichloroethene	1.2E+00	NA	6.77E-02	ND
1,1-Dichloroethane	NA	1.0E+00	ND	4.56E+03
2-Butanone	NA	3.0E-01	ND	6.42E+03
2-Hexanone	NA	NA	ND	ND
Acetone	NA	1.0E+00	ND	1.24E+04
Benzene	2.9E-02	NA	5.84E+00	ND
Bromodichloromethane	6.2E-02	2.0E-02	2.28E-01	2.43E+01
Bromoform	3.9E-03	NA	1.96E+02	ND
Carbon disulfide	NA	2.9E-03	ND	4.28E+01
Chloroform	8.1E-02	NA	1.82E+00	ND
Chloromethane	6.3E-03	NA	9.68E+00	ND
cis-1,2-Dichloroethene	NA	1.0E-01	ND	5.17E+02
Dibromochloromethane	6.4E-02	2.0E-01	5.63E+00	8.11E+03
Ethylbenzene	NA	3.0E-01	ND	6.66E+03
m- & p Xylenes	NA	3.0E-01	ND	9.58E+03
o-Xylenes	NA	3.0E-01	ND	8.04E+03
Tetrachloroethene	2.0E-03	NA	7.45E+01	ND
Toluene	NA	3.0E-01	ND	5.72E+03
trans-1,2-Dichloroethene	NA	2.0E-02	ND	2.16E+02
Trichloroethene	6.0E-03	NA	2.52E+01	ND
Vinyl chloride	3.0E-01	NA	4.97E-03	ND

NA – Not available

ND – Not Determined

SF inh – Slope Factor – inhalation exposure

RfD inh – Reference Dose – inhalation exposure

** Toxicity Information Sources: Integrated Risk Information System (IRIS), Accessed April 1995; and
Health Effects Assessment Summary Tables (1994).

* RfD inhalation values are subchronic where a subchronic value existed. Chronic values were used if no subchronic values existed.

Shading indicates that a route-to-route extrapolation was used where no toxicity values existed.

TABLE A-7
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
ON-SITE ENVIRONMENTAL SAMPLER
ORAL AND INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) [(SF_o \times 1E-06 \times IR_o) + (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))]}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	60 days/yr
ED	Exposure Duration	0.2 yr
SF_o	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
1E-06	Conversion Factor (kg/mg)	1E-06 kg/mg
IR_o	Oral Ingestion Rate (mg/day)	50 mg/day
SF_{INH}	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-8
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
ON-SITE ENVIRONMENTAL SAMPLER
ORAL AND INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) [(1/RfD_o) \times 1E-06 \times IR_o] + ((1/RfD_{INH}) \times IR_{INH} (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	25 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	60 days/yr
ED	Exposure Duration	0.2 yr
RfD_o	Oral Reference Dose (mg/kg/day)	Chemical-Specific
1E-06	Conversion Factor (kg/mg)	1E-06 kg/mg
IR_o	Oral Ingestion Rate (mg/day)	50 mg/day
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-9
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
ON-SITE EXCAVATION WORKER
ORAL AND INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) [(SF_o \times 1E-06 \times IR_o) + (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))]}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	120 days/yr
ED	Exposure Duration	0.33 yr
SF_o	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
1E-06	Conversion Factor (kg/mg)	1E-06 kg/mg
IR_o	Oral Ingestion Rate (mg/day)	50 mg/day
SF_{INH}	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-10
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
ON-SITE EXCAVATION WORKER
ORAL AND INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) [(1/RfD_o) \times 1E-06 \times IR_o] + [(1/RfD_{INH}) \times IR_{INH} (1/VF + 1/PEF)]}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	25 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	120 days/yr
ED	Exposure Duration	0.33 yr
RfD_o	Oral Reference Dose (mg/kg/day)	Chemical-Specific
1E-06	Conversion Factor (kg/mg)	1E-06 kg/mg
IR_o	Oral Ingestion Rate (mg/day)	50 mg/day
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-11
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE RESIDENTIAL ADULT RECEPTOR
INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	350 days/yr
ED	Exposure Duration	30 yr
IR_{INH}	Inhalation Intake Rate (m ³ /day)	15 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-12
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE RESIDENTIAL ADULT RECEPTOR
INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) (1/RfD_{INH} \times IR_{INH} (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	30 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	350 days/yr
ED	Exposure Duration	30 yr
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	15 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-13
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE RESIDENTIAL CHILD RECEPTOR
INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	15 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	350 days/yr
ED	Exposure Duration	6 yr
SF_{INH}	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	15 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-14
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE RESIDENTIAL CHILD RECEPTOR
INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) ((1/RfD_{INH}) \times IR_{INH} (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	15 kg
AT	Averaging Time (years)	6 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	350 days/yr
ED	Exposure Duration	6 yr
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	15 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-15
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE ADULT BIKER/WALKER
INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	140 days/yr
ED	Exposure Duration	30 yr
SF_{INH}	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-16
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE ADULT BIKER/WALKER
INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) (1/RfD_{INH} \times IR_{INH} (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	70 kg
AT	Averaging Time (years)	30 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	140 days/yr
ED	Exposure Duration	30 yr
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-17
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE CHILD BIKER/WALKER
INHALATION EXPOSURE:
CHEMICAL CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1E-06 \times BW \times AT \times 365}{(EF \times ED) (SF_{INH} \times IR_{INH} \times (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1E-06	Target Risk Level (unitless)	1E-06
BW	Body Weight (kg)	15 kg
AT	Averaging Time (years)	70 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	140 days/yr
ED	Exposure Duration	6 yr
SF_{INH}	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

TABLE A-18
SOIL PRELIMINARY REMEDIATION GOAL DEVELOPMENT
OFF-SITE CHILD BIKER/WALKER
INHALATION EXPOSURE:
CHEMICAL NON-CARCINOGENIC EFFECTS
(U.S. EPA, 1991)

$C_s = \frac{1.0 \times BW \times AT \times 365}{(EF \times ED) (1/RfD_{INH} \times IR_{INH} (1/VF + 1/PEF))}$		
Parameter	Parameter Description	Parameter Value Assumption
C_s	Chemical Concentration in Soil (mg/kg)	Chemical-Specific
1.0	Target Hazard Level (unitless)	1.0
BW	Body Weight (kg)	15 kg
AT	Averaging Time (years)	6 yr
365	Days/Year	365 days
EF	Exposure Frequency (days/year)	140 days/yr
ED	Exposure Duration	6 yr
RfD_{INH}	Inhalation Reference Dose (mg/kg/day)	Chemical-Specific
IR_{INH}	Inhalation Intake Rate (m ³ /day)	20 m ³ /day
VF	Volatilization Factor (m ³ /kg)*	Chemical-Specific
PEF	Particulate Emission Factor (m ³ /kg)	4.63 X 10 ⁹ m ³ /kg

* Refer to Table 20 for derivation of VF

Table A-19 Summary of Volatilization Factor Parameters for Granville Solvents (a)

Chemical	Theta	beta	ds	Kas	T	Di (b)	H (b)	Kd	Koc (b)	OC	Pt	Pa	Del	alpha	LS	V	DH	A	PI	VF	1/VF
1,1,1 - Trichloroethane	0.1	1.5	2.65	0.499	7.9E+08	0.078	1.72E-02	1.4125	141.25	0.01	0.433962	0.284	0.0063	0.000435	45	2.25	2	2.03E+07	3.14	5.9E+03	1.71E-04
1,1 - dichloroethene	0.1	1.5	2.65	0.952	7.9E+08	0.104	1.50E-02	0.6457	64.57	0.01	0.433962	0.284	0.0083	0.001041	45	2.25	2	2.03E+07	3.14	3.6E+03	2.81E-04
1,1 - Dichloroethane	0.1	1.5	2.65	2.091	7.9E+08	0.096	1.54E-02	0.302	30.2	0.01	0.433962	0.284	0.0077	0.001836	45	2.25	2	2.03E+07	3.14	2.3E+03	4.29E-04
2 - Butanone	0.1	1.5	2.65	0.145	7.9E+08	0.0808	4.35E-05	0.0123	1.23	0.01	0.433962	0.284	0.0065	0.000137	45	2.25	2	2.03E+07	3.14	1.1E+04	9.14E-05
2 - Hexanone	0.1	1.5	2.65	0.001	7.9E+08	0.078	4.35E-05	1.349	134.9	0.01	0.433962	0.284	0.0063	0.000001	45	2.25	2	2.03E+07	3.14	1.2E+05	8.48E-06
Acetone	0.1	1.5	2.65	0.277	7.9E+08	0.124	2.50E-05	0.0037	0.37	0.01	0.433962	0.284	0.0100	0.000396	45	2.25	2	2.03E+07	3.14	6.3E+03	1.58E-04
Benzene	0.1	1.5	2.65	0.284	7.9E+08	0.088	5.50E-03	0.7943	79.43	0.01	0.433962	0.284	0.0071	0.000287	45	2.25	2	2.03E+07	3.14	7.4E+03	1.35E-04
Bromodichloromethane	0.1	1.5	2.65	13.831	7.9E+08	0.09	2.05E-01	0.6166	61.66	0.01	0.433962	0.284	0.0072	0.004846	45	2.25	2	2.03E+07	3.14	6.2E+02	1.81E-03
Bromoform	0.1	1.5	2.65	0.015	7.9E+08	0.083	6.84E-04	1.8197	181.97	0.01	0.433962	0.284	0.0067	0.000015	45	2.25	2	2.03E+07	3.14	3.3E+04	2.99E-05
Carbon disulfide	0.1	1.5	2.65	0.233	7.9E+08	0.104	1.68E-02	2.9512	295.12	0.01	0.433962	0.284	0.0083	0.000281	45	2.25	2	2.03E+07	3.14	7.6E+03	1.32E-04
Chloroform	0.1	1.5	2.65	0.315	7.9E+08	0.104	3.39E-03	0.4416	44.16	0.01	0.433962	0.284	0.0083	0.000375	45	2.25	2	2.03E+07	3.14	6.5E+03	1.55E-04
Chloromethane	0.1	1.5	2.65	1.329	7.9E+08	0.126	8.14E-03	0.2512	25.12	0.01	0.433962	0.284	0.0101	0.001677	45	2.25	2	2.03E+07	3.14	2.7E+03	3.74E-04
cis - 1,2 - Dichloroethene	0.1	1.5	2.65	1.647	7.9E+08	0.1	3.19E-02	0.7943	79.43	0.01	0.433962	0.284	0.0080	0.001586	45	2.25	2	2.03E+07	3.14	2.6E+03	3.78E-04
Dibromochloromethane	0.1	1.5	2.65	0.039	7.9E+08	0.086	7.83E-04	0.8318	83.18	0.01	0.433962	0.284	0.0069	0.000039	45	2.25	2	2.03E+07	3.14	2.1E+04	4.82E-05
Ethylbenzene	0.1	1.5	2.65	0.145	7.9E+08	0.075	6.44E-03	1.8197	181.97	0.01	0.433962	0.284	0.0060	0.000127	45	2.25	2	2.03E+07	3.14	1.1E+04	8.81E-05
m & p - Xylenes	0.1	1.5	2.65	0.069	7.9E+08	0.077	6.27E-03	3.7154	371.54	0.01	0.433962	0.284	0.0062	0.000063	45	2.25	2	2.03E+07	3.14	1.6E+04	6.13E-05
o - Xylenes	0.1	1.5	2.65	0.098	7.9E+08	0.077	6.27E-03	2.6303	263.03	0.01	0.433962	0.284	0.0062	0.000089	45	2.25	2	2.03E+07	3.14	1.4E+04	7.30E-05
Tetrachloroethene	0.1	1.5	2.65	0.438	7.9E+08	0.072	2.90E-02	2.7164	271.64	0.01	0.433962	0.284	0.0058	0.000355	45	2.25	2	2.03E+07	3.14	6.5E+03	1.53E-04
Toluene	0.1	1.5	2.65	0.169	7.9E+08	0.087	6.68E-03	1.6218	162.18	0.01	0.433962	0.284	0.0070	0.000172	45	2.25	2	2.03E+07	3.14	9.8E+03	1.02E-04
trans - 1,2 - Dichloroethene	0.1	1.5	2.65	0.440	7.9E+08	0.1	6.32E-03	0.5888	58.88	0.01	0.433962	0.284	0.0080	0.000495	45	2.25	2	2.03E+07	3.14	5.5E+03	1.81E-04
Trichloroethene	0.1	1.5	2.65	0.391	7.9E+08	0.079	9.10E-03	0.955	95.5	0.01	0.433962	0.284	0.0063	0.000350	45	2.25	2	2.03E+07	3.14	6.6E+03	1.51E-04
Vinyl chloride	0.1	1.5	2.65	142.24	7.9E+08	0.106	8.50E-02	0.0245	2.45	0.01	0.433962	0.284	0.0085	0.008124	45	2.25	2	2.03E+07	3.14	6.5E+01	1.53E-02

(a) Volatilization factor derived per U.S. EPA Human Health Evaluation Manual, Part B: "Development of Risk-Based Preliminary Remediation Goals" (Dec 1991) and a memo from Janine Dinan to Regional Toxic Integration

Coordinators about changes to equations in the Part B Guidance, dated November 1992.

(b) PDER, 1990. Pennsylvania Department of Environmental Resources, "User's Manual for Risk Assessment and Transport (RAFT) Modeling System" July 13, 1990

Table A-20 Summary of Protective Soil Levels Based on Soil to Groundwater Migration – U.S. EPA MCL

$$\text{Soil level} = \text{Koc} \times \text{organic content} \times \text{MCL}$$

	Koc (L/kg) (a)	organic content	U.S. EPA MCL (ug/L) (b)	Estimated MCLG (ug/L) (c)	soil level DAF = 10 (ug/kg)
1,1,1-trichloroethane	141.25	0.01	200	–	2825.08
1,1-dichloroethene	64.57	0.01	7	–	45.20
1,1-dichloroethane	30.20	0.01	–	700	2113.97
2-butanone	1.23	0.01	–	4200	516.71
2-hexanone	134.90	0.01	–	–	ND
acetone	0.37	0.01	–	700	26.01
benzene	79.43	0.01	5	–	39.72
bromodichloromethane	61.66	0.01	100	–	616.60
bromoform	181.97	0.01	100	–	1819.70
carbon disulfide	295.12	0.01	–	700	20658.46
chloroform	44.16	0.01	100	–	441.57
chloromethane	25.12	0.01	–	44.1	110.77
cis-1,2-dichloroethene	79.43	0.01	70	–	556.03
dibromochloromethane	83.18	0.01	100	–	831.76
ethylbenzene	181.97	0.01	700	–	12737.91
m- & p-xylene	371.54	0.01	10000	–	371535.23
o-xylene	263.03	0.01	10000	–	263026.80
tetrachloroethene	271.64	0.01	5	–	135.82
toluene	162.18	0.01	1000	–	16218.10
trans-1,2-dichloroethene	58.88	0.01	100	–	588.84
trichloroethene	95.50	0.01	5	–	47.75
vinyl chloride	2.45	0.01	2	–	0.49

DAF – Dilution and Attenuation Factor based on the U.S.EPA DAF of 10

ND – Not Determined

NL – Not Listed

Sources:

(a) PDER. 1990. Pennsylvania Department of Environmental Resources.

"User's Manual for Risk Assessment and Transport (RAFT) Modeling System"
July 13, 1990.

Pollution Engineering. 1992. "Data Compilation for Soil Sorption Coefficients"
June 15, 1992.

(b) U.S. EPA. 1994. Drinking Water Regulations and Health Advisories. Office
of Water. November 1994.

(c) An MCLG was estimated for those chemicals without MCLs

Table A-21 Summary of Protective Soil Levels Based on Soil to Groundwater Migration – Region IX PRG

	Koc (L/kg) (a)	organic content	U.S. EPA Region IX PRG (ug/L) (b)	soil level DAF = 10 (ug/kg)
1,1,1-trichloroethane	141.25	0.01	1300	18362.99
1,1-dichloroethene	64.57	0.01	0.046	0.30
1,1-dichloroethane	30.20	0.01	810	2446.16
2-butanone	1.23	0.01	1900	233.75
2-hexanone	134.90	0.01	NL	ND
acetone	0.37	0.01	610	22.66
benzene	79.43	0.01	0.39	3.10
bromodichloromethane	61.66	0.01	0.18	1.11
bromoform	181.97	0.01	8.5	154.67
carbon disulfide	295.12	0.01	21	619.75
chloroform	44.16	0.01	0.16	0.71
chloromethane	25.12	0.01	1.5	3.77
cis-1,2-dichloroethene	79.43	0.01	61	484.54
dibromochloromethane	83.18	0.01	1	8.32
ethylbenzene	181.97	0.01	1300	23656.11
m- & p-xylene	371.54	0.01	1400	52014.93
o-xylene	263.03	0.01	1400	36823.75
tetrachloroethene	271.64	0.01	1.1	29.88
toluene	162.18	0.01	720	11677.03
trans-1,2-dichloroethene	58.88	0.01	120	706.61
trichloroethene	95.50	0.01	1.6	15.28
vinyl chloride	2.45	0.01	0.02	0.005

DAF – Dilution and Attenuation Factor based on the U.S.EPA DAF of 10

ND – Not Determined because a PRG for this chemical has not been derived.

NL – Not Listed

Sources:

(a) PDER. 1990. Pennsylvania Department of Environmental Resources.

"User's Manual for Risk Assessment and Transport (RAFT) Modeling System"
July 13, 1990.

Pollution Engineering. 1992. "Data Compilation for Soil Sorption Coefficients"
June 15, 1992.

(b) U.S. EPA, Region IX. 1995 EPA Region IX Preliminary Remediation Goals (dated 02/01/95).